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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Full Page Advt., page 73, June 25.

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See Advertisement page 46. 3409

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See Full Page Advertisement, June 25.

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See half-page Advert. last week and next week. 8490

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See half-page Advertisement page 137, July 9.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER. Chief Engineer: C. E. STROMEYER, M.I.C.E. Founded 1854 by SIR WILLIAM FAIRBAIRN. Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 8443

The Concrete Institute.

An Institution for Structural Engineers, Architects, etc.

EXAMINATIONS for Graduateship and for Associate-Membership will be held at the offices of the Institute on 14th and 15th OCTOBER, 1920. Forms of application and full particulars from the SECRETARY, Concrete Institute, Denison House, 296, Vauxhall Bridge Road, London, S.W. 1. H 590

Royal School of Mines

FRECHEVILLE RESEARCH FELLOWSHIPS.

THE IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, South Kensington, London, S.W. 7, with which the Royal School of Mines is incorporated, is OFFERING TWO RESEARCH FELLOWSHIPS of £300 a year each, tenable for one year, and possibly renewable for a second year, to aid in carrying out any investigation or research connected with Mining, Mining Geology, Metallurgy, or the Technology of Oil, which, in the opinion of the Selection Committee, is of sufficient use or promise.

Applicants, who may be Associates of the Royal School of Mines, or others, and preferably men with some practical experience, should apply, in writing, to the SECRETARY of the COLLEGE (from whom further particulars may be obtained), before 1st September, 1920, giving the nature of the proposed investigation, qualifications for the work and references.

It is anticipated that the Committee will make the awards by the end of November, so that the Fellowships and work may begin on 1st January, 1921. Holders will be expected to devote their whole time to the work, which may be conducted at the Imperial College or in special circumstances elsewhere at the discretion of the Committee. H 510

Inst. C.E. Exams.—Over 300

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TENDERS.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, &c., are prepared to receive

Tenders before Eleven

a.m., on Monday, July 26th, 1920, addressed to the SECRETARY, H.M. Office of Works, etc., Storey's Gate, Westminster, London, S.W. 1, for the SUPPLY of VENTILATORS during a period of six months from the date of acceptance of Tender.

Forms of Tender, etc., may be obtained on application to the CONTROLLER OF SUPPLIES, H.M. Office of Works, etc., King Charles Street, Westminster, London, S.W. 1. H 774

For Sale, New Copper and

PHOSPHOR BRONZE DISTILLATION COLUMNS, Plates and Cups type, with Rectifier and Condensers, complete, and with two copper still-pots of 2000 and 1000 gallons capacity respectively, fitted with copper heating coils, capable of acting singly or in series. The whole apparatus should be able to deal with 6-7000 gallons per day of benzene, acetone or alcohol, or can be used for acetic acid. Inspection and TENDERS INVITED.—Address, H 745, Offices of ENGINEERING.

SWANSEA HARBOUR TRUST.

STEEL RAILS AND FISHPLATES.

The Trustees invite

Tenders for the Supply and

DELIVERY, f.o.r. Prince of Wales Dock, Swansea, of the following:—

About 200 tons of 80 lbs. BULL-HEAD SECTION RAILS.

About eight tons of SHALLOW FISHPLATES to match.

About 180 tons of 80 lbs. FLAT-BOTTOMED SECTION.

About six tons of SHALLOW FISHPLATES to match.

The Rails and Fishplates to be in strict accordance with the British Standard Specifications.

Further particulars and Forms of Tender may be obtained at the Harbour Offices, from Mr. A. O. Schenk, the Trustees' Engineer.

Tenders sealed and marked "Rails and Fishplates," should be delivered to the undersigned on or before Wednesday, 4th August, 1920.

The Trustees do not bind themselves to accept the lowest or any Tender.

TALFOURD STRICK, (Clerk).

Harbour Offices, Swansea, 13th July, 1920. H 779

Aalborg Town Council has

decided, and the Department for Public Works approved, that the prizes in the

INTERNATIONAL COMPETITION FOR A NEW BRIDGE CONNECTION ACROSS THE LIMFJORD

are raised to the following amounts:

One First Prize	Kroner 15,000.00
One Second Prize ...	Kroner 10,000.00
One Third Prize	Kroner 5,000.00

The amounts for purchasing other plans—Kroner 2,000.00 for each—have not been altered.

THE COMMITTEE OF KING CHRISTIAN IX Pontoon Bridge.

Aalborg, July 5th, 1920. H 794

TO ENGINEERS AND OTHERS.

The METROPOLITAN ASYLUMS BOARD invite

Tenders for Installation of

LOW PRESSURE STEAM HEATING APPARATUS at the Mead Ambulance Station, Carnwath Road, Fulham, S.W. 6, in accordance with drawing and specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The drawing, specification and Form of Tender may be inspected at the Office of the Board, Embankment, E.C. 4., on and after 10 a.m. on Wednesday, 14th July, 1920, and the drawing, specification and Form of Tender can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a bona-fide Tender sent in accordance with the instructions on the Form of Tender, and after the specification and the drawing have been returned.

Tenders addressed as noted on the Form must be delivered at the Office of the Board not later than 2.30 p.m. on Monday, 26th July, 1920.

(By Order), DUNCOMBE MANN, Clerk to the Board. H 744

APPOINTMENTS OPEN.

UNIVERSITY OF LEEDS.

Demonstrator Required in the

Engineering Laboratory. Salary £200 per annum.

Duties to commence in the middle of September. Particulars on application from the SECRETARY. H 834

TECHNICAL SCHOOL, AUSTIN MOTOR CO., LTD., BIRMINGHAM.

Applications are Invited for

the POSITION of TEACHER of MATHEMATICS and ENGINEERING SCIENCE. Special knowledge of Automobile work not essential, but an Engineering College trained man preferred. Salary £325–£360 per annum.—Address, giving full particulars, MANAGER, Training Department, AUSTIN MOTOR CO., LTD., Longbridge Works, Northfield, Birmingham. H 630

DERBY TECHNICAL COLLEGE.

Applications are Invited for

the POSITION of:—

(1) ASSISTANT LECTURER IN PHYSICS;
(2) ASSISTANT LECTURER IN ENGINEERING SCIENCE (with Mathematics).

Salary in each case £240 to £450 per annum.

Qualifications and experience will be considered in fixing the commencing salary.

Forms of application may be obtained from the Principal.

FRANK C. SMITHARD, Secretary to the Derby Education Committee. July 2nd, 1920. H 586

GLAMORGAN EDUCATION COMMITTEE.

APPOINTMENTS OF LECTURERS IN MECHANICAL AND ELECTRICAL ENGINEERING.

The Committee propose to

Appoint Two Travelling

LECTURERS in Mechanical and Electrical Engineering, respectively. Applicants must possess special qualifications for teaching Engineering and allied subjects. Successful candidates must devote their whole time to the duties and reside where directed by the Committee, and will be required to commence duties in September next.

Salary £260 per annum, rising by annual increments of £15 to a maximum of £450 with expenses according to scale. In assessing the commencing salary regard may be had to previous full-time teaching experience in a recognised efficient school, subject to the case of service under other authorities to a limit of 10 years, and suitable experience in Works will also be taken into consideration. Canvassing will disqualify.

Applications, on forms which will be supplied on receipt of a stamped addressed foolscap envelope, must reach the CHIEF EDUCATION OFFICIAL, County Hall, Cardiff, by the 20th July, 1920. H 730.

CITY OF BRADFORD EDUCATION COMMITTEE.

TECHNICAL COLLEGE.

Applications are Invited for

the following APPOINTMENTS:—

ASSISTANT LECTURER in Physics.
" " " Chemistry.
" " " Dyeing.
" " " Electrical Engineering.
" " " Combing and Spinning.
" " " Weaving and Designing.

Salary in each case will be according to scale, rising to a maximum of £400 per annum. In fixing the initial salary, consideration will be given to qualifications and previous experience. (In addition to the salary, a bonus amounting at present to £35 10s. per annum in the case of men, and £67 12s. in the case of women, is also paid).

Applications, upon forms which may be obtained from the PRINCIPAL, Technical College, Bradford, should be forwarded not later than Saturday, 24th July, 1920.

By Order. H 741

BOROUGH POLYTECHNIC INSTITUTE, LONDON, S.E. 1.

The Governors require at an early date the

Services of a Lecturer and

DEMONSTRATOR in the Engineering Department. Candidates must possess a Degree or be otherwise qualified, and should have had workshop and teaching experience.

Salary commencing at £315, rising by £10 to £440. Particulars of the appointment and Forms of Application may be obtained by sending stamped addressed foolscap envelope.

C. T. MILLIS, Principal. H 798

TECHNICAL INSTITUTE, WALTHAMSTOW. Principal—JAMES G. B. EDWARDS, A.M.I.M.E.

The Governors invite

Applications for the following

POSTS in the Day Department of the Technical Institute:—

TWO LECTURERS in Engineering Subjects. Commencing salary £360 per annum.

Candidates should possess a University degree, or its equivalent, and should have had practical workshop experience.

Teachers appointed will have the opportunity of taking evening work, for which additional payment will be made.

Application Forms, which must be returned by July 20th, may be obtained from R. DEMPSEY, Clerk to the Governors, 1, Selborne Road, Walthamstow. H 849

CITY OF CARDIFF EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE. Principal - CHARLES COLES, B.Sc. (Lond.)

The Services are Required of

a LECTURER in MARINE ENGINEERING, whose duties will be concerned mainly with the preparation of sea-going Engineers for all grades of Board of Trade Certificates.

Commencing salary £450 per annum, rising by annual increments of £20 to £550 per annum.

Candidates must preferably possess the Extra First Class Board of Trade Certificate, combined with a sound scientific training.

Applications, on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three testimonials, should reach the PRINCIPAL on or before Tuesday, July 20th, 1920.

JOHN J. JACKSON, B.A., City Hall, Director of Education. Cardiff. H 629

SWINDON EDUCATION COMMITTEE.

SWINDON AND NORTH WILTS TECHNICAL INSTITUTION.

Principal: MR. G. H. BURKHARDT, M.Sc.

ASSISTANT LECTURER IN ENGINEERING.

Applications are Invited for

this POST. Degree or diploma essential, and works experience desirable. The gentleman appointed will be required to assist with the teaching of Practical Mathematics and general Engineering subjects, and to take special responsibility for Electrical Engineering.

Salary according to new scale, with allowance for previous experience, either in teaching or in works.

Immediate application should be made to THE PRINCIPAL, Technical Institution, Swindon, who will supply, on request, forms of application, copies of the scale of salary, and any further particulars which may be desired.

W. SHATON, Secretary. H 707

MERSEY DOCKS AND HARBOUR BOARD.

PRINCIPAL ASSISTANT TO ENGINEER-IN-CHIEF.

The Mersey Docks and Harbour Board invite

Applications for the Position

of PRINCIPAL ASSISTANT to their Engineer-in-Chief.

Applications with copies of testimonials, stating age, qualifications and salary required, to be addressed to the undersigned not later than Saturday the 4th day of September, 1920.

In addition to being a fully qualified Civil Engineer, applicants should have a good knowledge of Mechanical and Electrical Engineering.

By Order of the Board, L. A. P. WARNER, General Manager and Secretary. Dock Office, Liverpool, 8th July, 1920. H 693

HENDON URBAN DISTRICT COUNCIL.

APPOINTMENT OF ENGINEERING ASSISTANT.

The above Council invite

Applications for the Appoint-

ment of an ENGINEERING ASSISTANT in the Engineer and Surveyor's Department. Applicants must be fully qualified engineers with good experience in the design and construction of municipal engineering works.

Commencing salary £350 per annum (inclusive of war bonus), rising by annual increments of £25 to £500 per annum.

Applicants must not be more than 30 years of age. In cases where applicants have served in H.M. Forces, and who are over the maximum age, the period of service with H.M. Forces will be allowed as an addition to the age limit.

Application on Forms to be supplied for the purpose, accompanied by copies of not more than three testimonials and service record, and endorsed "Engineering Assistant," to reach the undersigned not later than Saturday, the 24th instant.

Canvassing directly or indirectly will be a disqualification.

Dated this 8th day of July, 1920. HENRY HUMPHRIS, Clerk to the Council.

Town Hall, Hendon, N.W. 4. H 766

NORTHAMPTON POLYTECHNIC INSTITUTE. CIVIL AND MECHANICAL ENGINEERING DEPARTMENT.

ELECTRICAL ENGINEERING AND APPLIED PHYSICS DEPARTMENT.

Wanted, An Assistant

LECTURER and DEMONSTRATOR in each of the above departments. Salary £325 to £315 according to experience and qualifications. Conditions and forms of application, which must be returned not later than Tuesday, 20th July, 1920, can be obtained from R. MULLINEUX WALMSLEY, D.Sc., Principal, Northampton Polytechnic Institute, E.C. 1. H 704

ASSISTANT INSPECTOR OF WIRELESS TELEGRAPHY, GENERAL POST OFFICE.

There is at present a

VACANCY for an ASSISTANT INSPECTOR OF WIRELESS TELEGRAPHY in the Post Office. Candidates should preferably be between 25 and 28 years of age; they should be graduates in Physics or Electrical Engineering (preferably with post-graduate experience in an electrical laboratory or workshop, or they should have had experience as Naval or Military Experts); and they must have had practical experience of Wireless Telegraphy and Electrical Engineering. They will be required to pass a medical examination and may be called on to serve abroad. Salary, £300 to £350 by increments of £15 a year, and then to £450 by increments of £20. In addition, War Bonus is paid on the Civil Service scale, which, at the present rates, would increase a salary of £300 to £390; £350 to £911; and £450 to £757. Applications, with full particulars of qualifications and experience, and copies of recent testimonials, should be sent to the SECRETARY, General Post Office, London, E.C. 1, on or before the 31st July. H 601

CITY OF BRADFORD.

SMOKE INSPECTOR.

The Health Committee invite

Applications for the Appoint-

MENT of a SMOKE INSPECTOR.

Applicants should have a sound knowledge of the construction of furnaces and all other appliances, mechanical and otherwise, used for the raising of steam and the proper combustion of fuel.

Commencing salary £260, rising £26 per annum on approved service to a maximum of £375, plus war bonus of £85 16s., and an allowance in lieu of uniform.

Applications in candidates own hand writing, stating age, previous experience, together with copies of not more than three recent testimonials, should be sent to the undersigned not later than 22nd July, 1920.

JOHN J. BUCHAN, Town Hall, Medical Officer of Health. Bradford. H 769

Foundry Manager Required

to take charge of, and be responsible to the Management of Main Jobbing, Machine and Plate Moulding, and Gunmetal Foundries. These are separate foundries. Applicant must have had experience in loam, dry and green sand work, and be thoroughly conversant with all the latest and up-to-date mechanical appliances for quick and successful production. Applications will only be entertained from those who have held a similar position.—Apply, with full particulars of experience and salary required, to W. H. ALLEN SONS & CO., LTD., Queen's Engineering Works, Bedford. H 807

Manager Wanted for Factory

manufacturing White Sulphate of Lead, must have good organising ability, some engineering knowledge would be most useful. Fullest particulars in confidence, of experience, qualifications, age and salary by letter to SULPHATE, c/o POOL'S Advertising Service, 130, Fleet Street, E.C. 4. H 734

Iron Foundry Works Manager

REQUIRED for new Foundry, near London, used to castings up to five tons, output 30 tons per week.—Address, giving full particulars of experience and salary required, H 834, Offices of ENGINEERING.

General Manager Wanted for

small Agricultural Implement Works. Must have experience of the trade. One able to invest £1/2000 preferred.—Address, IMPLEMENT, WM. PORTEOUS & Co., Advertising Agents, Glasgow. H 824

Technical Assistant Required

in a Research Department, to elaborate flow-sheets of processes, plot graphs, and assist in design of laboratory apparatus, some drawing office experience, and sound knowledge of chemistry required, good opportunity for Engineering Graduate. Salary £250.—Address, H 714, Offices of ENGINEERING.

Technical Assistant.—Box No.

H 10 desires to thank the many applicants for this POSITION and to inform them that it has been FILLED. H 784

Wanted by Motor Manufac-

turers, FIRST-CLASS OPERATORS, able to set own work on Gridley Single Spindle Automatics. Reply, giving full particulars and wages expected.—Address, H 742, Offices of ENGINEERING.

Wanted by Motor Manufac-

turers, SETTERS, used to high-class work on Gridley Single Spindle Automatics. Reply, giving full particulars and wages expected.—Address, H 743, Offices of ENGINEERING.

Wanted, in a General Engi-

neering Factory abroad, an experienced COST CLERK, capable of preparing Estimates, etc., and conversant with modern factory methods. A knowledge of Spanish is desirable.—Applicants should write, stating age, whether married or single, and salary required, to C. C. R., c/o STREETS, 30, Cornhill, London, E.C. 3. H 757

A Man with wide experience

of Ship Construction, and of good personality, REQUIRED, to travel and introduce a new device of great importance for ships of all sizes and types. Applicants should have *entrée* to shipbuilders and shipowners. Salary £480 to £500 per annum. Reply, enclosing copies of testimonials giving age and full particulars of experience.—Address, H 808, Offices of ENGINEERING.

THE WORKS OF MESSRS. ROBEY AND CO., LIMITED, AT LINCOLN.

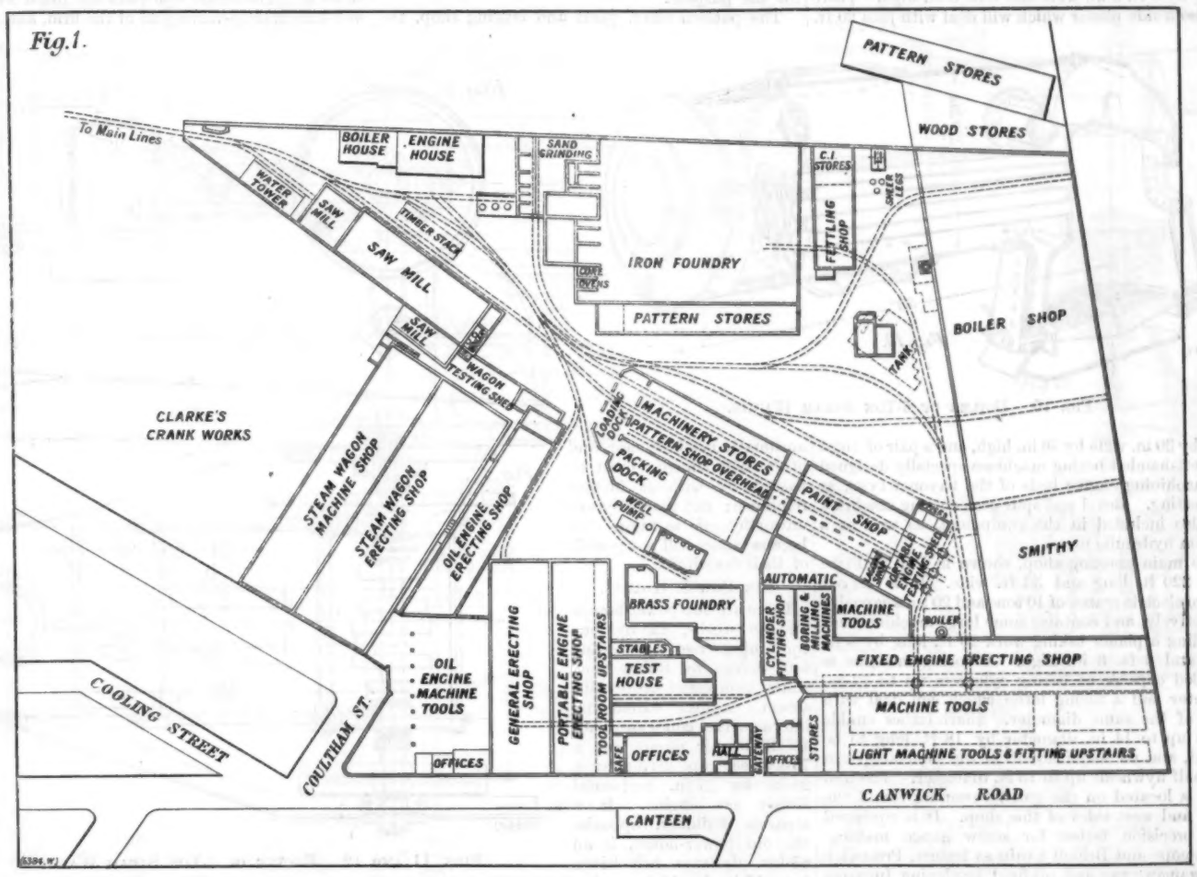
THE association of the country of Lincolnshire with the manufacture of agricultural machinery has long been noteworthy, and the position of the City of Lincoln as an important engineering centre is largely due to the enterprise shown there in the development of steam machinery for agricultural purposes. Agricultural steam engines and machines still remain perhaps the principal mechanical products of the city, but for many years now the manufacture of engines of all kinds and of machinery having no relation to agriculture has constituted a very important branch of local activity. The firm of Messrs. Robey and Co., Limited, illustrates in many respects the engineering history of the City of Lincoln. It was founded about the middle of the last century, and in its early days the manufacture of agricultural engines and threshing machines occupied its entire energies. Portable, traction and ploughing engines were followed by the stationary undertype engines, a compact type of prime mover in which the cylinders were placed horizontally underneath the smoke-box of a locomotive boiler and the crankshaft was situated just in front of the firebox. The accessibility of this arrangement and its convenience for many industrial purposes led to its wide adoption, both at home and abroad. The success of this engine led to the development of other types, such as drop-valve engines, the high-speed enclosed engines for electric lighting purposes, winding engines and Uniflow engines. Air compressors were also taken up, semi-Diesel oil engines, electric winding gear, and decorticating machinery for fibres became also specialities of the firm, while steam wagons are likewise a very important product as road traction has never ceased to be one of the principal lines of Messrs. Robey's activities since the earliest days. The manufacture of threshing and kindred machines has been discontinued, as the firm preferred to devote its energies entirely to the heavier classes of engineering work.

Messrs. Robey and Co., we may mention, constructed, at their Lincoln Works, the engines for the first public electric lighting installation in London, these engines driving the dynamos by belts.

The founder of the firm was Mr. Robert Robey, who started in a small way of business in Lincoln in 1854. Some few years later the works were taken over by Messrs. John Richardson, Thomas Bell and Frederick Clench, the latter being subsequently bought out by the other partners. It was incorporated as a limited company in 1893, the chairman at the present time being Mr. Alexander Trotter, while Mr. W. T. Bell, O.B.E., the son of one of the former partners, is managing director.

The present works, in Canwick-road, Lincoln, occupy a site of more than 12 acres and give employment to about 2,000 persons. Their general lay-out is shown in the plan, Fig. 1, on the present page. The plot of land occupied is somewhat irregular, as must necessarily be the case when firms have grown from small beginnings and have had to extend in unforeseen directions as the developments of the business have demanded. Nevertheless the newer shops are handsome structures as will be seen from the various internal views which we publish in this issue, and to which we shall refer later.

Fig. 1.



The steam wagon department, which is entirely devoted to the manufacture of the Robey 5-ton steam wagon, comprises two bays, each 290 ft. in length. The erecting bay, illustrated in Fig. 2, Plate IX, accompanying the present issue, is 78 ft. wide, and the machine bay shown in Fig. 3, on the same Plate, is 60 ft. wide. The detail assembly of the smaller parts is carried out on the gallery which runs down one side of the machine bay. At the time of our visit the latter shop was not fully equipped owing to the difficulty of getting delivery of the special machine tools wanted, but production was nevertheless proceeding on a scale which indicated a future output of considerable magnitude. The other portions of the works are at present being drawn upon for some of the machining work, but in due course the steam wagon department will be entirely self-contained and operated in accordance with the most modern ideas of quantity production. The present equipment comprises a Sunderland gear planer, Buck bevel gear cutter, Gardner crank-pin lathe, Lapointe broaching machine, vertical boring mills by Stirk, horizontal boring machines by Dickinsons, and numerous other tools of the latest type. Needless to say the fullest use is made of jigs and fixtures as an aid to accurate and rapid machining, and piecework is applied to all operations. A stores for finished work is situated at one end of the machine shop, whence details are issued to the assemblers as required. Every piece has to pass through the stores and is inspected before acceptance. In the erecting shop the construction of the wagons is carried out on equally systematic lines. The assemblage of units takes place at one end of the shop and the wagon passes on from gang to gang, each bringing it one stage nearer completion until it reaches the other end ready for its engine test, which is carried out in an adjacent test shed. A running test on the road follows the engine test, and the bodies are then fitted and the vehicles painted ready for delivery. A brief description of the Robey steam wagon will be given later.

Figs. 4, 5 and 6, on Plates X and XI, give a good idea not only of the main engine erecting shops of Messrs. Robey and Co., but of the nature of the work carried out in them. But although a large proportion of the output of the firm consists of Uniflow and Drop-valve engines and air compressors of the slow-speed horizontal type, the manufacture of vertical high-speed engines and air compressors either of the open type or totally enclosed, is also a very substantial branch of their activity. The view of the test beds, in Fig. 7, Plate XI, taken at a time when a large and urgent Government order for wireless generators was going through confirms this. These, as will be observed, are of the open type, but high speed totally-enclosed forced lubrication engines are equally a standard product.

We do not propose to give a detailed description

of the various shops which go to compose the works of Messrs. Robey and Co., but rather to describe a few of the more important products which the firm manufacture. Before entering upon this latter part of the subject, however, it will be well to mention a few facts concerning the principal shops in order to give some idea of the magnitude and capacity of the works. The Uniflow-engine erecting shop, illustrated in Fig. 4, Plate X, is 350 ft. long by 37 ft. wide, and is served by three electric travelling cranes and two rope-driven cranes, ranging in lifting power from 5 tons to 20 tons. In this and the adjoining bay are some very large machine tools, including flywheel lathes taking work up to 22 ft. diameter, surfacing lathes capable of turning material 46 in. diameter by 25 ft. 6 in. long, a planing machine taking work up to 20 ft. long by 6 ft. 9 in. wide and 6 ft. 6 in. high. There is also a side planer which will deal with jobs 20 ft.

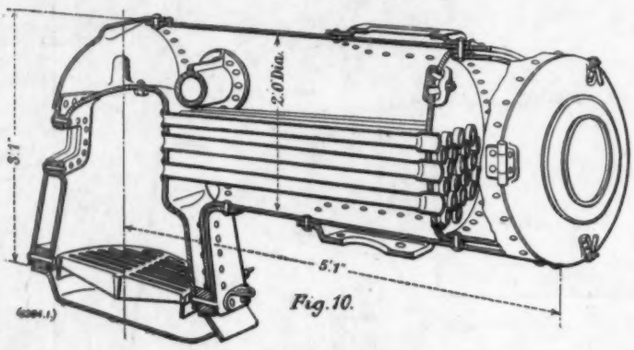


FIG. 10. BOILER OF 5-TON STEAM WAGON.

long by 30 in. wide by 36 in. high, and a pair of right and left-handed boring machines specially designed for machining engine beds of the bayonet type, at one setting. Bevel and spur gear cutting machines are also included in the equipment, as well as a 110-ton hydraulic press.

The main erecting shop, shown in Fig. 5, Plate X, is 220 ft. long and 56 ft. wide. It is served by two electric cranes of 10 tons and 20 tons capacity respectively, and contains some large machine tools including a planer taking work 20 ft. long by 8 ft. wide and 6 ft. 6 in. high. A boring machine is installed capable of boring cylinders up to 72 in. diameter and a facing lathe which can deal with work of the same diameter. Shaft lathes enable shafts up to 14 in. diameter by 18 ft. long to be turned, and an Asquith drill in the same shop can drill half flywheels up to 15 ft. diameter. The tool room is located on the gallery running round the south and west sides of this shop. It is equipped with precision lathes for screw gauge making. Scleroscope and Brinell hardness testers, Prestwich fluid gauges, gas and oil-fired hardening furnaces complete with pyrometers, and other appurtenances of a modern tool room. Another gallery contains small machine tools upon which apprentices are trained.

A second erecting shop, 220 ft. long by 60 ft. wide, having a gallery along one side, is used for the erection of traction engines, portable engines, stone breakers, &c. At one end of this shop a space is reserved for machine tools, and the whole shop is served by two 20-ton travelling cranes.

The oil engine department comprises two shops, one 160 ft. long by 80 ft. wide, which contains the offices of the department as well as about 40 machine tools of various kinds, and the other, which is 200 ft. long by 42 ft. wide, serves as an erecting shop for both land and marine oil engines. At the end of this shop are the oil-engine test beds, which are equipped with dynamometers and all other apparatus necessary for exact and convenient testing.

The boiler shop, which is 340 ft. long by 155 ft. wide, contains the usual hydraulic presses, plate furnaces, plate bending rolls, shearing machines, &c. Both electric and acetylene welding plants are installed, and the cutting of plates by the acetylene process is largely carried out. Hydraulic riveting is practised wherever possible. The smiths' shop, contains eight Massey Steam hammers, ranging from 10 cwt. to 50 cwt., and five drop-stamps, ranging from 8 cwt. to 25 cwt. The iron foundry, which is 215 ft. long by 160 ft. wide, is served by three cupolas capable respectively of melting 1 ton, 3 tons and 5 tons per hour. A hydraulic truck hoist raises the coke and pig-iron to the charging platform. Electric travelling cranes of 15 tons, 20 tons and 25 tons respectively work over the moulding floor.

The brass foundry, 120 ft. long by 42 ft. wide, contains five natural draught furnaces capable of melting 1,400 lb. of brass per day, and a pair of coke-fired core ovens are also installed. In the iron foundry there are eight core ovens, four fired by coke and four by a producer gas plant installed for the purpose.

The pattern shop, paint and lagging shop, the automatic machine shop and other departments must be passed by without further reference; not that they are unworthy of mention but because space will not permit of their description.

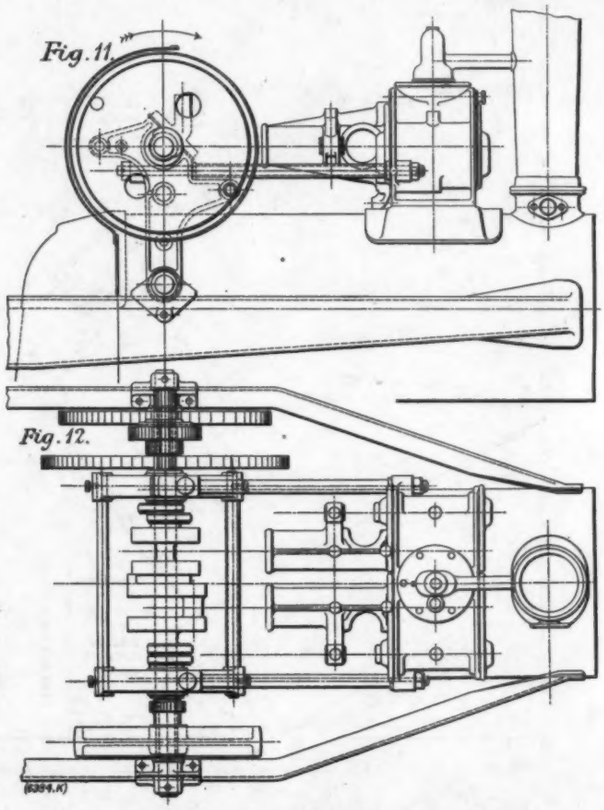
THE POWER HOUSES.

There are two power houses on the works, the old one containing two generating sets driven by Robey horizontal compound drop-valve steam engines exhausting into a surface condenser with Le Blanc air pump, and a 75-kw. set rope-driven by a 20-in. by 27-in. horizontal Robey gas engine. In a separate building, opposite the old power-house, is an 85-kw. dynamo belt-driven by a 15-in. by 18-in. under-type Uniflow engine. The total rated capacity of the old plant is 660 kw., and the current is generated at 220 volts. Steam is supplied to this plant, and to the test beds also by a range of five loco-type boilers and a Parker boiler. An independently-fired superheater enables the superheat of the steam to be regulated as desired.

The new power-house is a fine building, its dimensions being 150 ft. by 40 ft., inclusive of the boiler room, which covers nearly half the total area. This room contains two watertube boilers with economisers and superheaters, having a combined rated evaporative capacity of 32,000 lb. per hour. The boilers are constructed for a working pressure of 220 lb. per square inch, and are equipped with chain-grate stokers and coal elevators. A motor-driven fan provides induced draught. The boiler feed pumps are by Messrs. Weir, and a Boby softener is about to be installed. Each boiler is equipped with its own feed-water meter, and a CO_2 recorder is fitted so that it can be connected to either boiler at will. In addition to these aids to efficiency a Sarco recording steam meter continuously measures the quantity of steam generated, and recording wattmeters are provided to register the output of the main generators.

The engine-room contains two 220-volt direct current generators, the larger being driven by a Robey Uniflow engine having a cylinder 35-in. bore by 40-in. stroke rated at 1,250 h.p. when running at 120 r.p.m. The smaller set has an Uniflow engine of 29 in. diameter by 30 in. stroke, running at 140 r.p.m. Both engines have forced lubrication and are equipped with jet condensers, the air pumps of which are driven from the engine crankshafts. Shaft governors, mounted on the lay shafts, control the speed by varying the cut off.

There is also in the engine room a compound steam-driven two-stage air compressor of Messrs. Robey's own manufacture. This machine, which delivers air at 80 lb. per square inch, has steam cylinders 13 in. and 23 in. diameter, and air cylinders 23 in. and 14 in. diameter, all with a stroke of 36 in. The steam cylinders are fitted with the well-known drop-valve gear of the firm, and the air



FIGS. 11 AND 12. ENGINE OF 5-TON STEAM WAGON.

cylinders have the Robey patent disc valves and unloading device which will be described later. Another engine room contains a 500 kw. generating set driven by a totally-enclosed high-speed engine, and a 100-kw. motor generator set for reducing the city voltage to the pressure used at Messrs. Robey's works.

THE ROBEY STEAM WAGON.

There are many points of interest with regard to the 5-ton steam wagon, illustrated in Figs. 8 and 9, on Plate XII, and in Figs. 10 to 12, on the present page. The boiler is of the locomotive type, but is specially noticeable for the reason that the firebox is entirely free from stays either on the top or at the sides. Similarly there are no stays for the fire-box casing, so that not only is the water circulation unhindered, and cleaning very greatly simplified, but the chances of leakage are practically done away with. The general construction of the fire-box and casing will be gathered from Figs. 8 and 10, the latter showing these parts in section. The fire-box is pressed from a single plate and, after the pressing operation, is somewhat like a bath in shape. If the fire-box shown in Fig. 10 were divided through its centre by a vertical plane at right angles to the length of the boiler barrel, the part containing the

MOTOR-DRIVEN AIR COMPRESSOR; CAPACITY 5000 CUBIC FEET PER MINUTE.

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

Fig. 13.

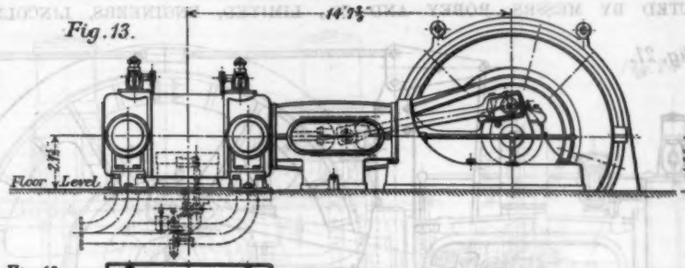


Fig. 14.

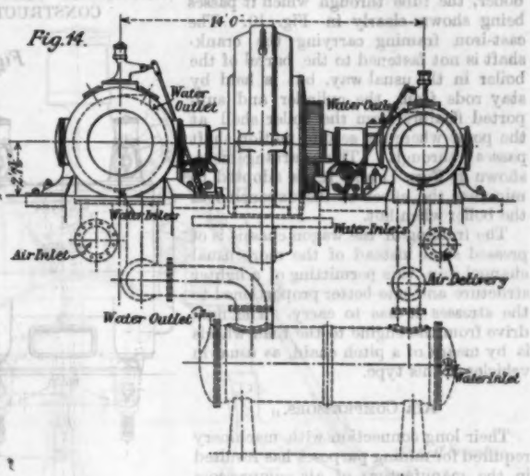


Fig. 15.

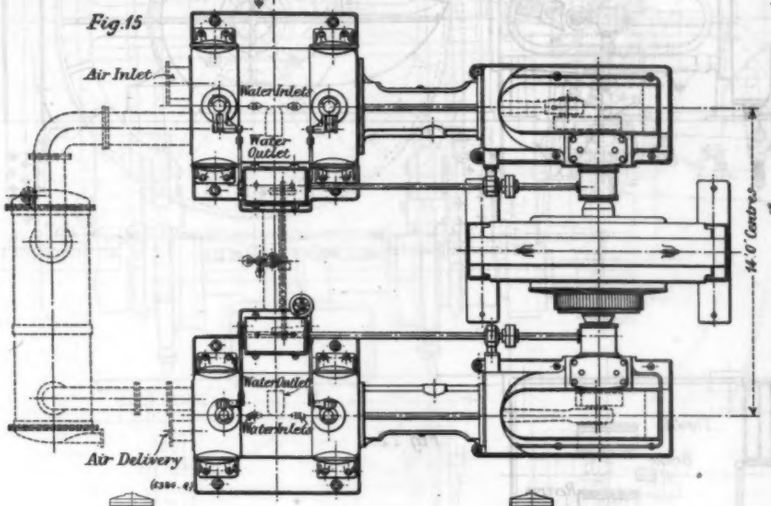


Fig. 18.

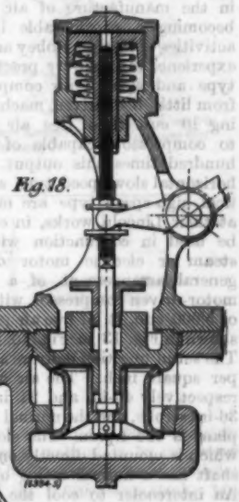


Fig. 16.

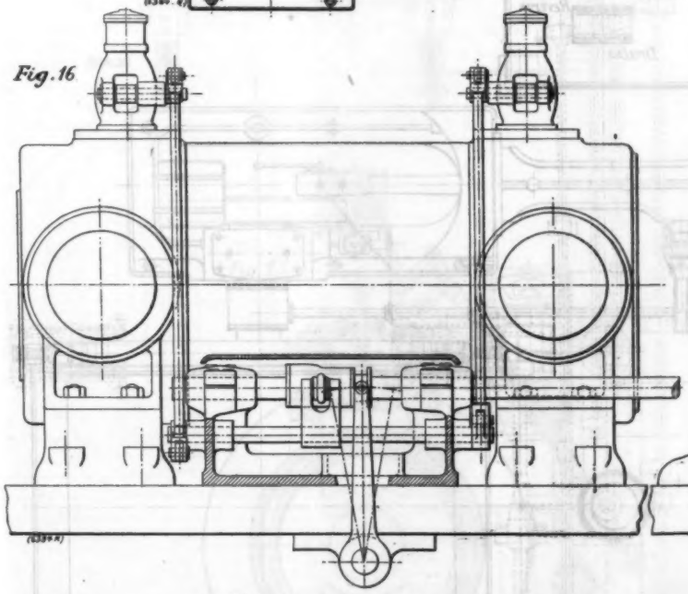
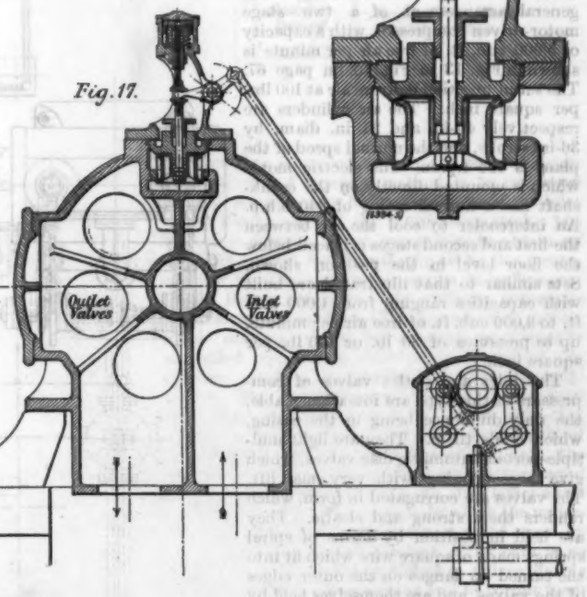


Fig. 17.



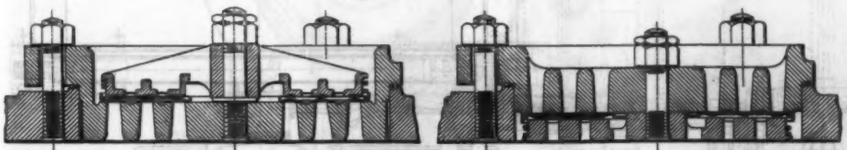


Fig. 19.

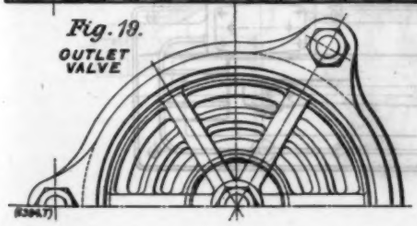
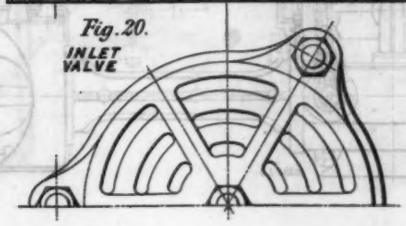


Fig. 20.



fire door could obviously be removed and fitted to the other part with the semicircular lower end of each part in contact. This would give the bath-like shape referred to, and after the plate is pressed into this shape it is cut transversely across the centre of its length, and the two parts welded together along what were their top edges. Thus a complete fire-box is made, having only one welded seam and no riveted seams. Moreover, except for the flattened part where the tubes enter, the fire-box is everywhere of circular section, so that the necessity of staying is eliminated. The skirt of the casing is also circular, and the top plate is approximately spherical, diverging from this ideal shape only in so far as small flattened surfaces have been pressed on it for the purpose of forming seatings for the boiler

fittings. The function of these small flats will be well seen from Fig. 8.

It will be also noticed that the second motion shaft is carried right through the boiler, the tube through which it passes being shown clearly in Fig. 10. The cast-iron framing carrying the crank-shaft is not fastened to the barrel of the boiler in the usual way, but is held by stay rods from the cylinder and supported flexibly from the boiler shell at the point where the second motion shaft passes through. This arrangement, shown in Figs. 11 and 12, is adopted to minimise the effect of the expansion of the boiler when hot.

The framing of the wagon chassis is of pressed steel instead of the more usual channel iron, this permitting of a lighter structure and one better proportioned to the stresses it has to carry. The final drive from the engine to the road wheels is by means of a pitch chain, as usual in vehicles of this type.

AIR COMPRESSORS.

Their long connection with machinery required for mining purposes has resulted in the manufacture of air compressors becoming a considerable item in the activities of Messrs. Robey and Co. Their experience ranges over practically every type and size of air compressor made from little belt-driven machines delivering 10 cub. ft. of free air per minute to compressors capable of about one hundred times this output. Both the horizontal slow speed type and the vertical high-speed type are manufactured at their Lincoln works, in each case to be used in conjunction with either a steam or electric motor drive. The general arrangement of a two-stage motor-driven compressor, with a capacity of 5,000 cub. ft. of free air per minute is shown in Fig. 13 to Fig. 15, on page 67. The set in question delivers air at 100 lbs. per square inch. The air cylinders are respectively 40-in. and 24 in. diam. by 36-in. stroke, and the normal speed of the plant is 105 r.p.m. The electric motor which is mounted directly on the crank-shaft has a normal rating of 940 b.h.p. An intercooler to cool the air between the first and second stages is placed below the floor level in the position shown. Sets similar to that illustrated are built with capacities ranging from 1,000 cub. ft. to 8,000 cub. ft. of free air per minute, up to pressures of 80 lb. or 100 lb. per square inch.

The inlet and outlet valves of compressors of this type are interchangeable, the only difference being in the casing, which holds them. They are light multiple-ported automatic disc valves, which give large openings with very small lift. The valves are corrugated in form, which renders them strong and elastic. They are held in position by means of spiral springs made of square wire which fit into the turned up flanges on the outer edges of the valves, and are themselves held by their guide plates. The arrangement will be understood by reference to Fig. 19 and Fig. 20, page 67. The valves are thus held firmly on their seatings and are free to move upwards without any sliding friction. There is a complete absence of guide studs, which need lubrication and are liable to wear, and the valves can seat themselves freely and quietly at each stroke.

In order to enable compressors of this type to be operated economically at partial load when driven by a constant-speed motor, it is necessary to introduce some form of automatic unloading device, which will prevent the compression of

WINDING ENGINES WITH DROP VALVES.

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

Fig. 21.

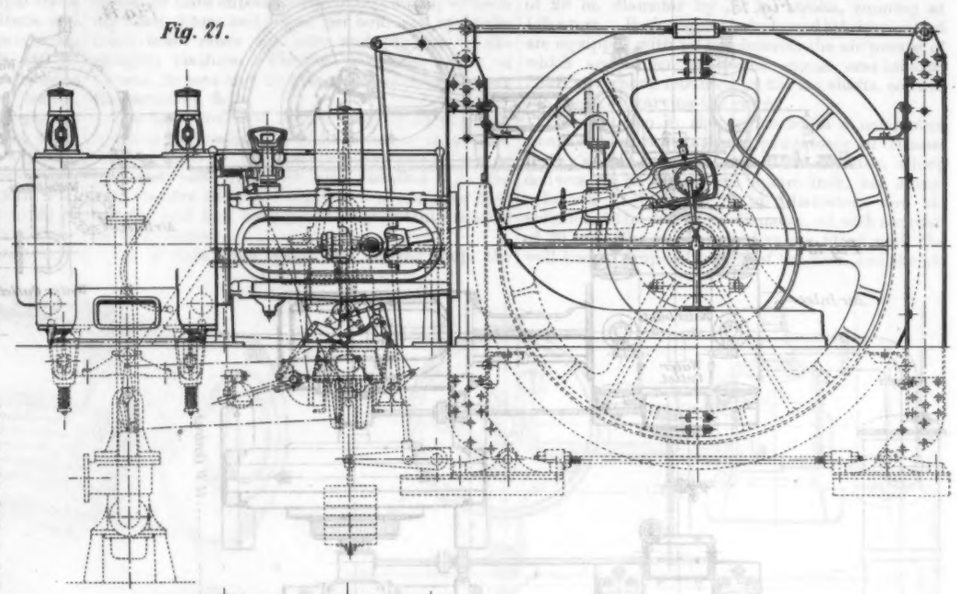
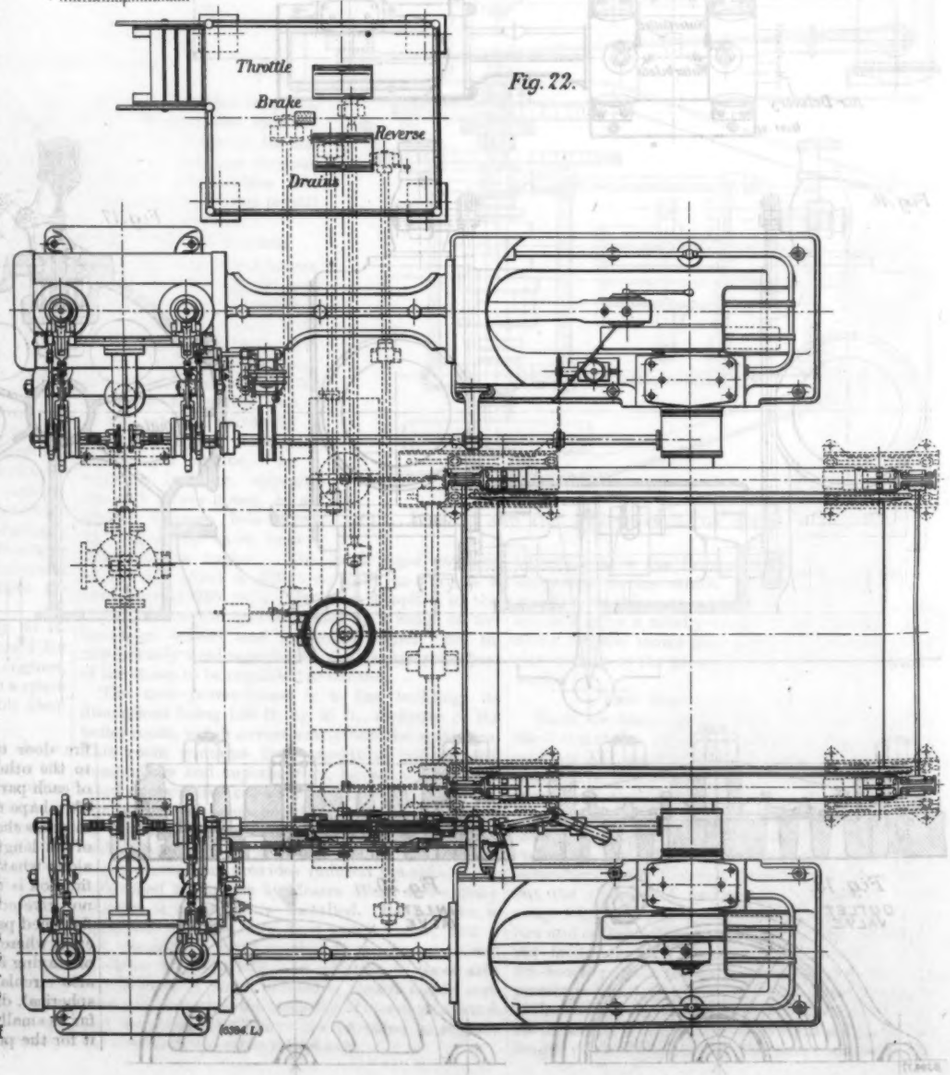


Fig. 22.



WINDING ENGINES WITH DROP VALVES.

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

Fig. 23.

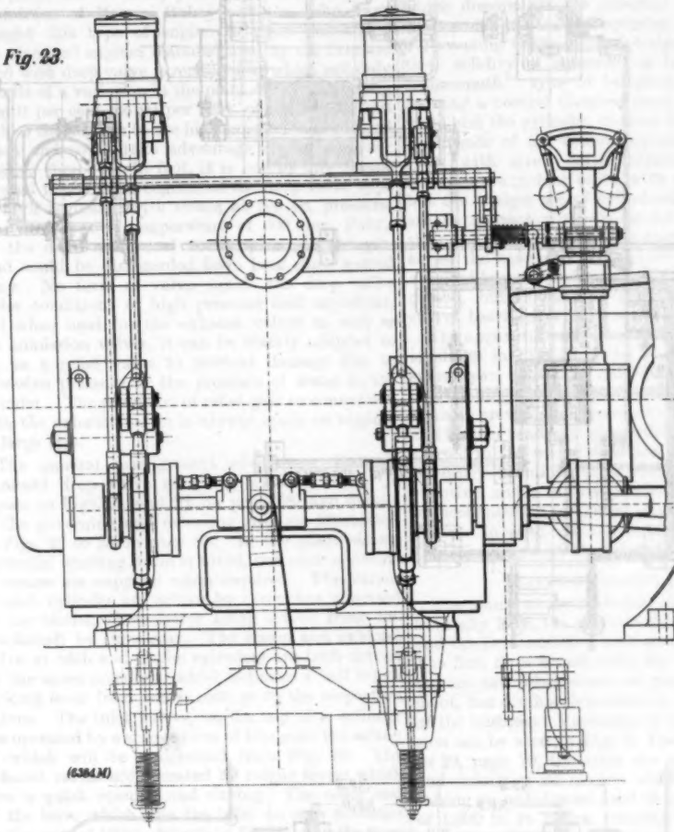


Fig. 24.

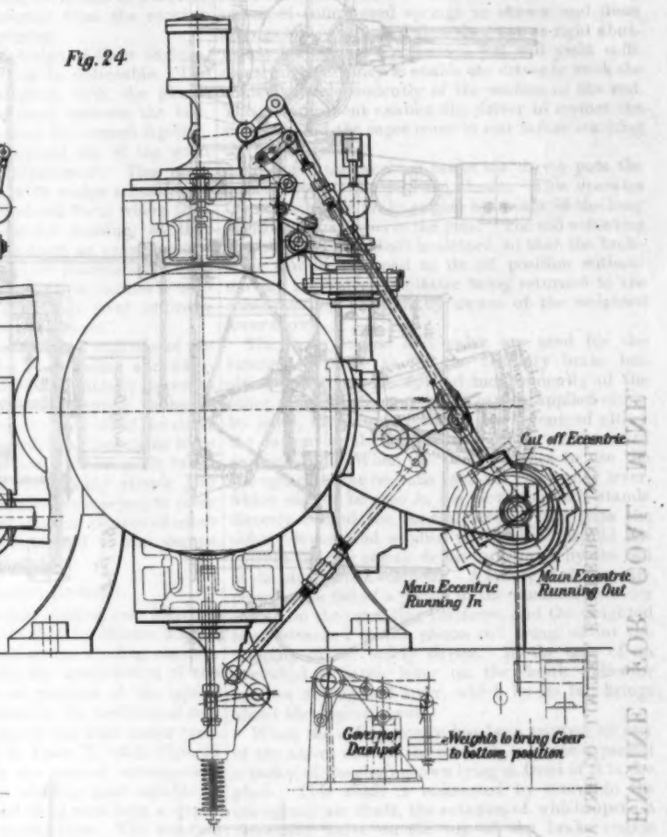
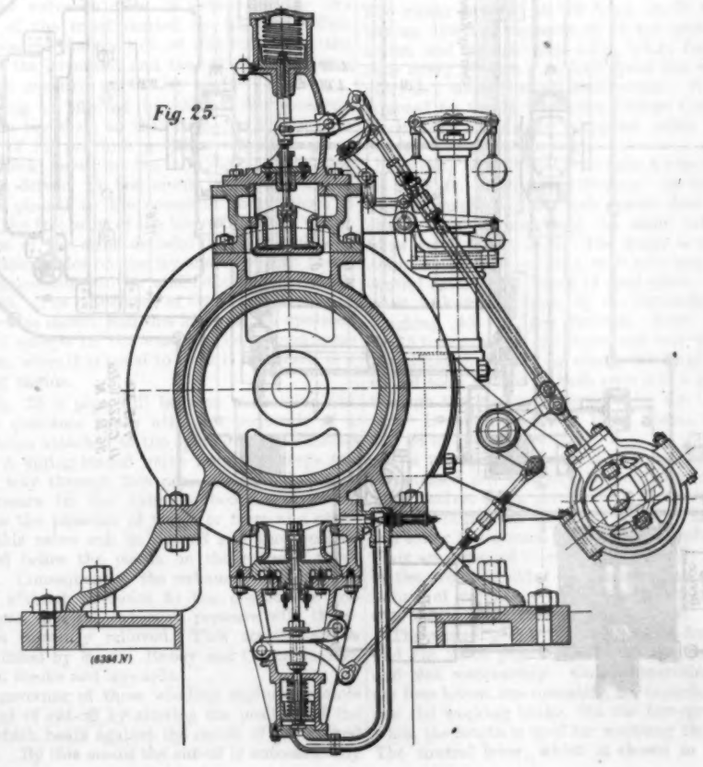

Cut off Eccentric
Main Eccentric Running In
Main Eccentric Running Out
Governor Dashpot
Weights to bring Gear to bottom position

Fig. 25.



more air than is needed to keep the pressure up in the receiver. A common method is to use some form of mechanism for holding open one of the inlet valves during part of the compression stroke, but it is very difficult, if not impossible, to obtain an adequate passage for the escaping air by this means, and any throttling of the air results in inefficiency. In the Robey compressor the ordinary automatic inlet valves are unaffected by the unloading device, which consists of an independent mechanically controlled equilibrium valve at each end of the cylinder, working in parallel with the automatic valves. The arrangement will be understood from Figs. 16 to 18 on page 67. The unloading valves are operated by a lay shaft at the side of the cylinder. On this shaft is a sliding cam, the position of which is determined by a lever keyed to a transverse shaft beneath it. The latter shaft is connected to the air governor, in which the underside of a spring-balanced piston is acted upon by the air pressure in the receiver. The cam is so shaped as to open the equilibrium valves during the whole of the suction strokes and to permit them to close at a time depending upon the amount of air required on the compression strokes. Thus, if the compressor is running at half load the equilibrium valves will not close until about half the compression stroke is completed, thus allowing the air drawn in on the suction stroke to flow freely back during the first part of the compression stroke to the atmosphere or intercooler, as the case may be. The same cam operates both the equilibrium valves belonging to any cylinder by means of the two roller levers shown in Fig. 17. It will be seen that the unloading gear gives a continuous range of unloading, and as the valve mechanism is always in motion there is no fear of it sticking through disuse. It has the further advantage of promoting high volumetric efficiency, as it permits

ELECTRIC WINDING ENGINE FOR COAL MINE.

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

Fig. 26.

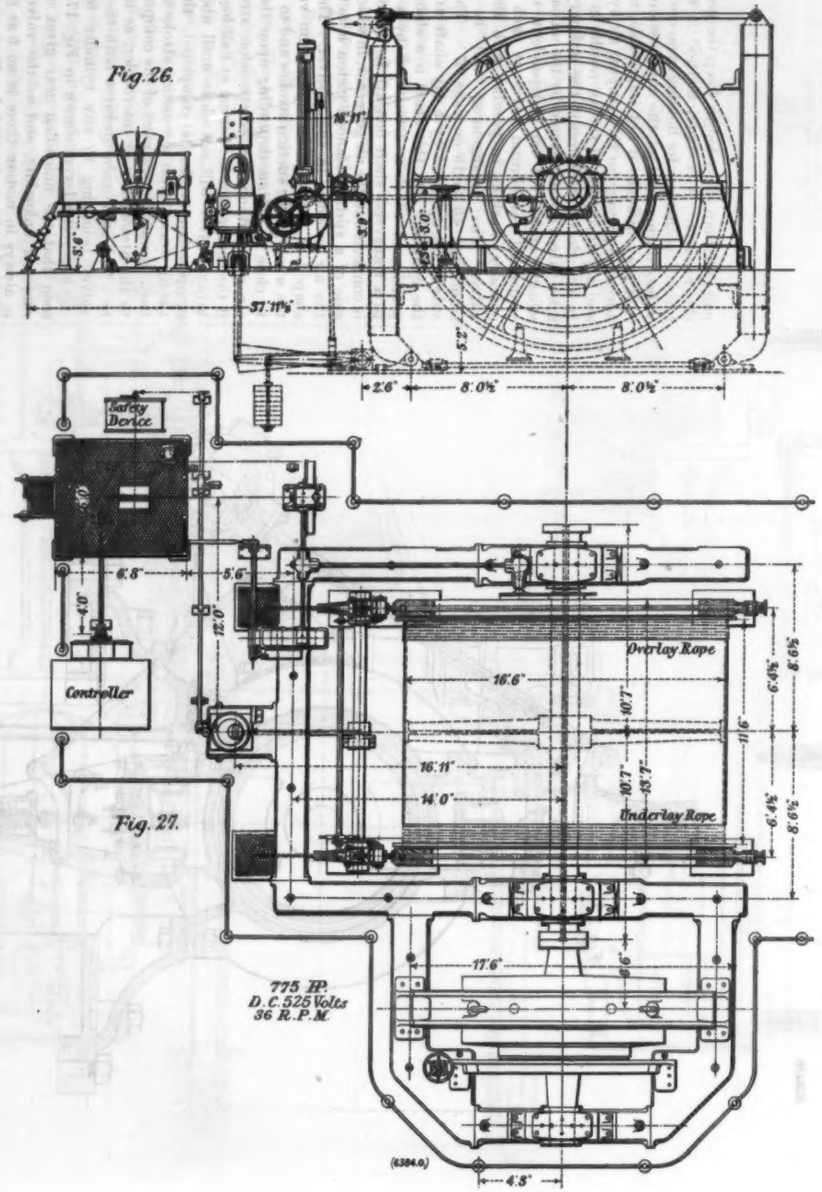


Fig. 27.

Fig. 28.

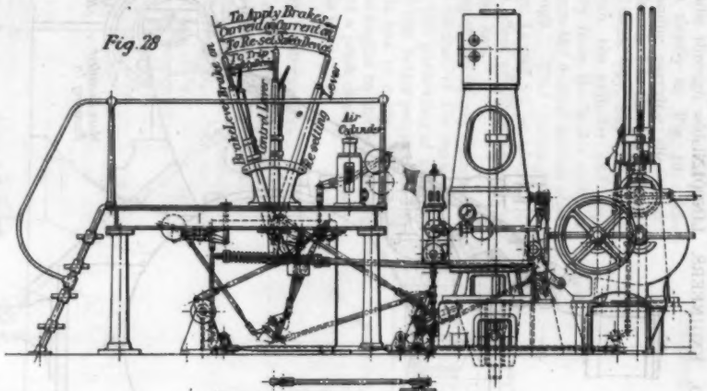
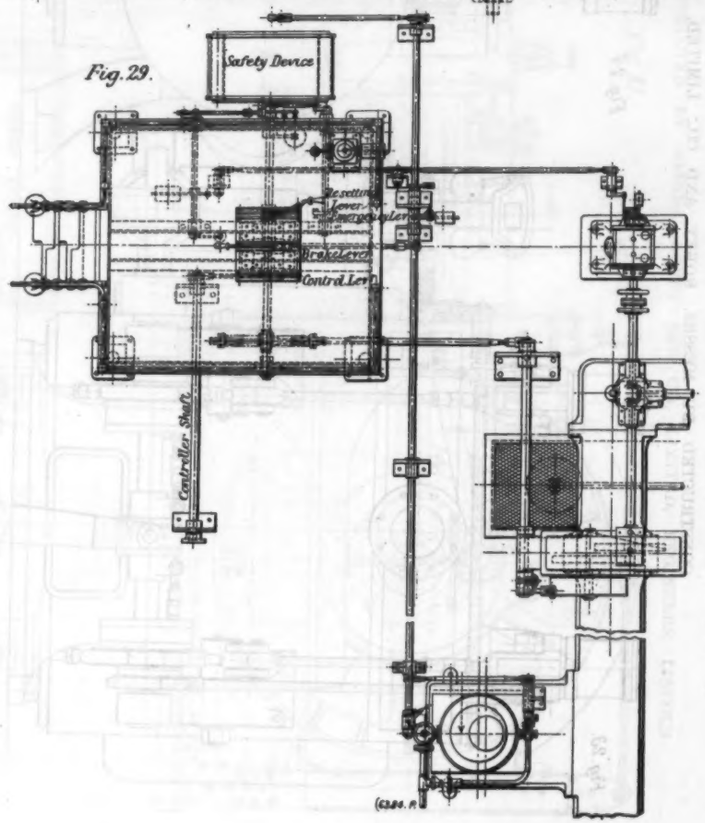


Fig. 29.



the freest possible admission of air to the cylinder during the suction stroke.

DROP VALVE WINDING ENGINES.

The manufacture of steam winding engines for coal mines has for many years past been one of the specialities of Messrs. Robey and Co., who have brought this type of engine to great perfection. The standard engines manufactured by the firm are fitted with drop valve reversing gear which not only permits of a variation in the point of cut-off ranging from 0 per cent. to 90 per cent. of the stroke, but enables the engines to use high pressure superheated steam and so to take advantage of the economy possible thereby. In fact, it is not by any means unusual for winding engines of the drop valve type to work regularly with steam at 200 lb. pressure, superheated to a temperature of 600 deg. Fahr., for the days when coal consumption at the pit-head could be disregarded have long since passed away. No form of valve equals the drop valve under conditions of high pressure and superheat, and when used for the exhaust valves as well as the admission valves, it can be readily adapted to act as a relief valve to prevent damage due to excessive pressure or the presence of water in the cylinder. The provision of relief gear in connection with the exhaust valves is always made on engines of large size.

The general arrangement of Messrs. Robey's standard drop valve reversing winding engine is shown on Figs. 21 and 22 on page 68, and details of the governing and reversing gear are illustrated in Figs. 23 to 25 on page 69. In the plant shown a parallel winding drum is fitted, but conical drums of course are supplied when required. The valves of each cylinder are driven by eccentrics mounted on lay shafts, these latter being driven from the crankshaft by skew-gear. The steam and exhaust valve at each end of the cylinders are both driven by the same eccentric, which actuates a bell crank rocking lever from which rods go to the respective valves. The inlet valves, on the top of a cylinder are operated by a simple form of trip gear, the action of which will be understood from Fig. 25. The exhaust valves are operated by rolling levers which give a quick opening and closing. The outer end of the lever which lifts the inlet valve is actuated by the curved tripper shown in Fig. 25, and the time when this tripper releases the valve lever and allows the valve to close, is determined by the position of the roller carried by the link. Two factors control the position of this roller, one the height of the governor, and the other the position of a small eccentric on the lay shaft.

Reversing is effected by sliding the eccentric across the lay shaft so that it stands 180 deg. in advance of its previous position. It slides on a square block keyed to the lay shaft, which also acts as a driver. A bell crank lever, one arm of which is pinned to the eccentric body causes it to slide, the free arms of the levers belonging to the eccentrics of the same cylinder being linked to a sleeve which slides on the lay shaft between them. The arrangement will be understood by reference to Fig. 23. The movement of the sleeve is effected by a lever as shown, and this lever can be operated by hand except in the case of the largest sizes of engine, when it is usual to work it by means of a reversing engine.

In Fig. 25 a pipe will be seen connecting the cylinder clearance space with the underside of a small piston attached to the spindle of the exhaust valve. A spring-loaded valve normally keeps the passage way through this pipe closed, but should the pressure in the cylinder become excessive owing to the presence of water or from any other cause, this valve will be opened and the pressure admitted below the piston on the exhaust valve spindle. Consequently, the exhaust valve will be opened without reference to the position of the valve gear, and the excessive pressure will, therefore, be instantly relieved. This attachment is always fitted by Messrs. Robey and Co. to engines of 60 in. stroke and upwards.

The governor of these winding engines controls the point of cut-off by altering the position of the roller which bears against the inside of the curved tripper. By this means the cut-off is automatically varied over a continuous range extending from zero up to nine-tenths of the stroke. The governor is also thrown automatically out of action when reversing takes place, so that the engineman can throw full steam against his engine when winding at full speed. This is effected by means of a clutch, which disconnects the governor from the rocking shaft which it normally operates.

Reverting to the general design of these engines, their solidity of construction is noticeable. The "Mammoth" type of bedplate, with the guides forming a central distance piece between the bedplate and the cylinder, ensures the utmost rigidity. Both ends of the connecting-rod are of the solid type, with screw cotter adjustment. The main bearings are in four parts, with wedge adjustment, but the wedges are of cylindrical form where they are in contact with the metal housing, so that their flat faces are bound to exert an even pressure across the bearings. The whole bearing is, in fact, a swivel bearing so far as horizontal motion is concerned, but it has the advantage over ordinary swivel bearings of wedge adjustment.

The apparatus seen in connection with one of the layshafts in Fig. 22 is the overwinding and overspeed gear, which not only automatically prevents overwinding or overspeed when coming to bank, but also prevents overspeed at any point of the shaft and further renders it impossible for the engine to be started in the wrong direction. Although it fulfils so many functions it is remarkably simple and effective, and is in fact supplied as a separate piece of mechanism to safeguard winding engines of other types. In such cases it is geared to the engine crankshaft by a pitch chain.

ELECTRIC WINDING ENGINES.

The manufacture of electric winding gear followed naturally from the position held by Messrs. Robey and Co. in connection with steam winding engines. The firm do not undertake the construction of the motors and other electrical portions of the equipment, but confine themselves to the mechanical side of the business. Machinery of this kind under erection can be seen in Fig. 5, Plate X, while Figs. 26 to 29, page 70, illustrate the general arrangement and details of an electric winding gear capable of raising an unbalanced load of 12 tons from a depth of 1,800 ft. in 70 sec. running time. The winding engine is driven by a direct-coupled continuous current motor fitted with Ward Leonard control. The motor is rated at 775 b.h.p. at 36 r.p.m. It has an overload capacity of 15 per cent. for two hours, and will develop 1,210 b.h.p. for 14 secs. once every 90 secs. At half speed the motor will exert 2·2 times the full load torque. It was constructed by the Metropolitan Vickers Company, of Manchester, who also supplied other electrical details.

The duty of the plant is to raise 4 tons of coal up an 1,800-ft. shaft every 90 secs. In addition to the net weight of coal, each double deck cage and chairs weigh 6 tons, and the eight tubs it contains weigh 5 cwt. each. The drum is 16 ft. 6 in. diam. by 11 ft. 6 in. wide, with cast iron sides and central spider, and barrel of steel plate. The rope is of locked coil type, 5½ in. circumference and weighing 45 lb. per fathom. Each rope has 34·75 live turns on the drum and four dead turns. The drum shaft is 17 in. diam., with half couplings forged solid with it at both ends and a hole drilled through the centre as required by the Coal Mines Act. It runs in bearings 15 in. diam., and 22 in. and 28 in. long respectively.

The two post brakes and gear are operated by compressed air, a Robey steam-driven compressor with receiver being provided for the purpose. The brakes will hold an unbalanced load of 12 tons, and will lower the normal load without undue heating. They are arranged to come automatically into action in the event of either an overwind, an overload, a failure of voltage, or a failure of air pressure, so that safety is abundantly provided for.

The control gear will be understood from Figs. 28 and Fig. 29 on page 70, which show it in elevation and plan respectively. On the operating platform are four levers, one operating the electric controller, one the working brake, one the emergency brake, while the fourth is used for resetting the trip gear. The control lever, which is shown in the "off" position, is connected by links with the controller shaft underneath the platform and gives the shaft a partial rotation. The same lever is also connected by a horizontal rod and shaft to the accelerating and retarding cams, but the connection is not a rigid one. The force is transmitted to the rod by means of compressed springs as shown, and these springs are so adjusted that they act as rigid abutments for ordinary pressures, but will yield sufficiently in emergency to enable the driver to work the controller independently of the motion of the rod. This arrangement enables the driver to restart the motor should the cages come to rest before reaching the landing stage.

To apply the working brake the driver puts the brake lever to the position shown. This operates the valve of the brake engine by means of the long horizontal shaft seen in the plan. The rod actuating the lever on this shaft is slotted, so that the brake lever can be returned to its off position without moving the valve, the latter being returned to the corresponding position by means of the weighted lever shown.

The same engine and valve are used for the emergency brake as for the ordinary brake but either brake can be applied independently of the other. The emergency brake can be applied either by hand, or automatically in the event of either the current or the air pressure failing or in case of an overwind. When the driver wishes to use the emergency brake he pulls back the emergency lever, which cannot be seen in the elevation as it stands directly behind the control lever. This trips the safety device and applies the brake. Should the current fail the safety device is tripped by the fall of the plunger of a solenoid. A failure of air pressure permits the fall of a piston in the small air cylinder shown on the operating platform, and the weighted lever attached to the piston rod brings about the tripping of the safety device. In the case of an overwind a catch lever on the depth indicator releases a weighted lever, which by its fall brings about the desired result.

When the safety device has been tripped by any of the above causes, the result is to cause a partial rotation of the shaft shown lying in front of it in the plan. This shaft is connected by levers to the emergency air shaft, the rotation of which opens a three-way valve on the top of the brake engine cylinder. Thus air is admitted to the top of the piston, very greatly increasing the braking effect. The pedal seen on the platform is to enable the trip to be reset after an overwind. Its function is to hold up the weighted lever on the depth indicator until the cage is returned to the decking level, when it is automatically held in readiness to act again in case of another overwind.

(To be continued.)

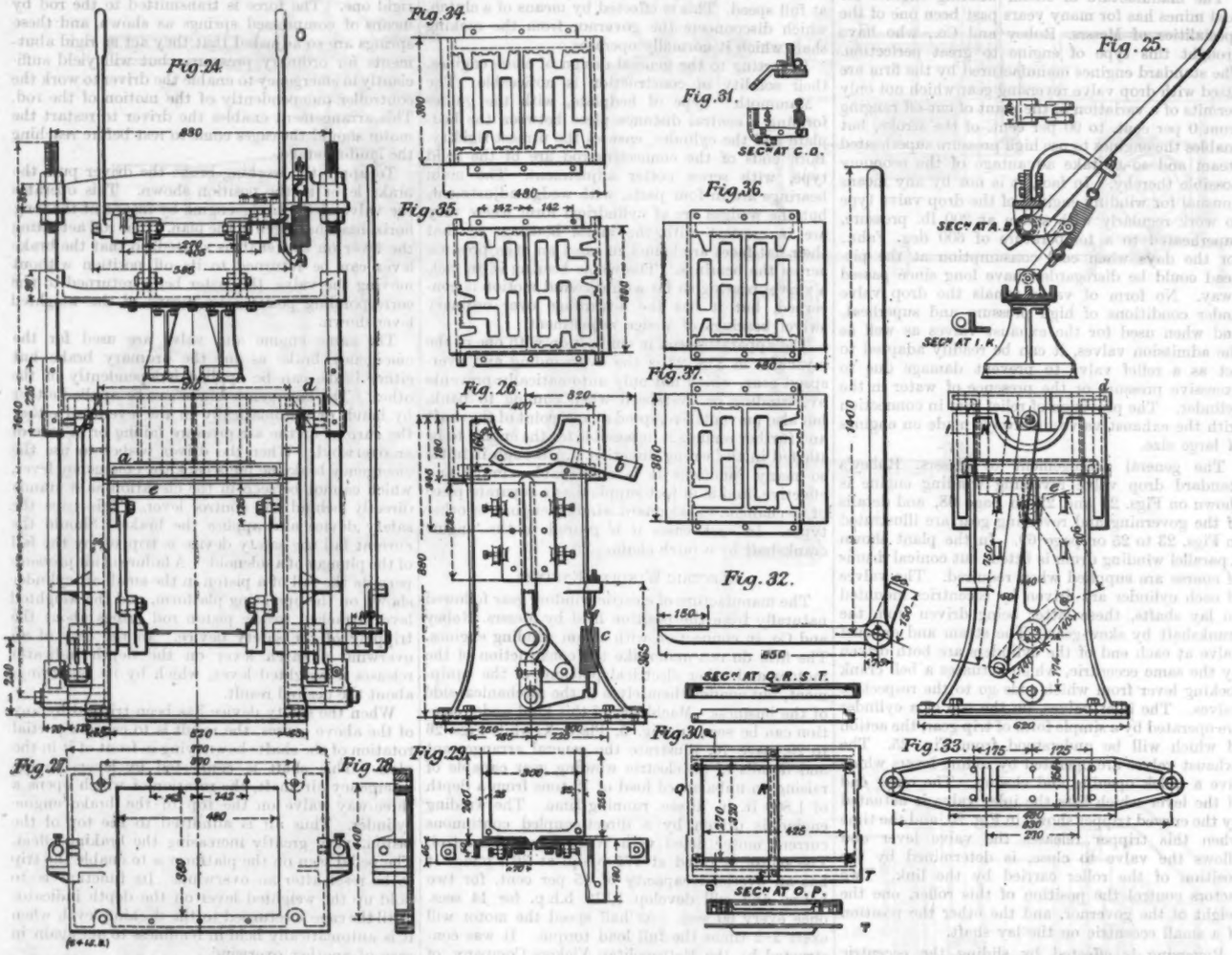
THE ROYAL AGRICULTURAL SHOW AT DARLINGTON.

(Concluded from page 46.)

THE increasing price of timber and of labour has no doubt had much to do with the increased use of concrete for constructional purposes in connection with agriculture, as with other industries, but the watertight and vermin-proof nature of the material and its sanitary properties make it especially applicable to many of the purposes of the farmer. There was considerable evidence at Darlington that its advantages are becoming appreciated, and on many of the stands were shown concrete fence posts, building blocks, &c. But the most elaborate stand of all devoted to the concrete industry was that held by the Concrete Utilities Bureau of Great St. Helens, London, E.C. 3. This was a most striking exhibit and exemplified the use of concrete for scores of purposes of the most diverse description. Stable floors, mangers, feeding racks, tanks, ornamental garden posts, lamp-posts, and vases, artistically-shaped sundial stands, railway sleepers besides, of course, building blocks and fences of various descriptions were on view. The concrete post and rail fences were very good work, smaller apparently in scantling than the usual wooden fences of the type, and, of course, indestructible by weather or insects. The concrete tanks were

MACHINE FOR MAKING "AERO" CONCRETE BUILDING BLOCKS.

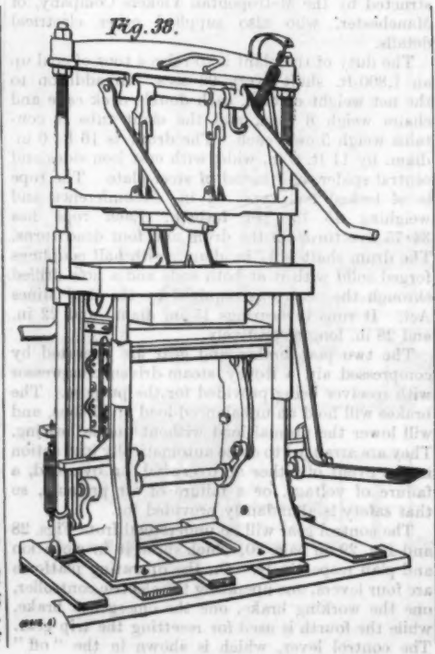
CONSTRUCTED BY MESSRS. S. THORNELY, MOTT AND VINES, LIMITED, LONDON.



apparently about 1½ in. thick, reinforced with wire netting and the hardness and smoothness of their finish was all that could be wished. A portion of a wall, including a moulded Tudor window frame, was shown, the external surface of which could not be distinguished from natural stone. The concrete blocks had, in fact, been faced with about ½ in. of yellow stone-like material made by mixing ground yellow stone with cement. The surface was afterwards tooled, and the illusion was perfect. Other building blocks were moulded to resemble roughly-dressed stone, and here again one could hardly detect the deception.

The Concrete Utilities Bureau, however, did not rest content with the mere display of finished articles and structures, but gave practical demonstrations of the actual process of manufacture. The mixing of the concrete, the filling and tamping of the moulds, and the removal of the article were all performed in public, while a capable lecturer called attention to the points which had to be regarded in order to ensure successful results. The facilities enjoyed by visitors of examining the moulds and noting every detail of the process of manufacture of various articles must have been of great educational value, and will surely be reflected in the greater and more efficient use of Portland cement, which is presumably what the exhibitors desired.

Grouped around this stand were the stands of numerous firms showing concrete block-making machinery, of various degrees of elaborateness. Amongst the simplest was a small hand-power



machine, called the Manelite, and exhibited by Mr. C. J. Mannell, of Poole Hill, Bournemouth. In this machine the concrete was tamped into a mould, adjustable in size, made of four cast-iron side plates. By pulling a hand lever a top plate was caused to descend and flatten the top edge of the slab, and the latter was then pushed up out of the mould by the rise of the bottom plate which was forced up through the mould by a wire rope and hand lever. The arrangement was very effective, and could hardly have been simpler. The same firm make a hydraulically-operated machine for use when very large outputs are required.

Messrs. Wingel, Limited, of 25, Victoria-street, London, S.W. 1, showed a very complete range of concrete-making machinery, including block-making machines, elevators, mixers, stone crushers and, in fact, almost everything necessary for carrying out concrete building work on a large scale. Other exhibitors of block or slab-making machinery, mixers, &c., were Messrs. Stothert and Pitt, Limited, of Bath, William Benson and Co., of Leeds; Henry Wilde, 8, Manor Park, Lewisham, S.E.; Vickers, Limited, Broadway, Westminster; the Channello Construction Company, Grays Inn, London, W.C.; R. G. Whitaker, Limited, 22, Southwark Bridge-road London, S.E. 1; the Liner Concrete Machinery Company, Maling-street, Newcastle-on-Tyne; and the British Lean Company, Limited, 11, Suffolk-street, Pall Mall, London, S.W.

Messrs. S. Thornely Mott and Vines, Limited, of 11 Old Queen-street, Westminster, S.W. 1, showed a machine for making the "Aero" concrete building

PORTABLE POWER HOIST

CONSTRUCTED BY MESSRS. ARTHUR CLAYDEN AND CO., ENGINEERS, RICHMOND.

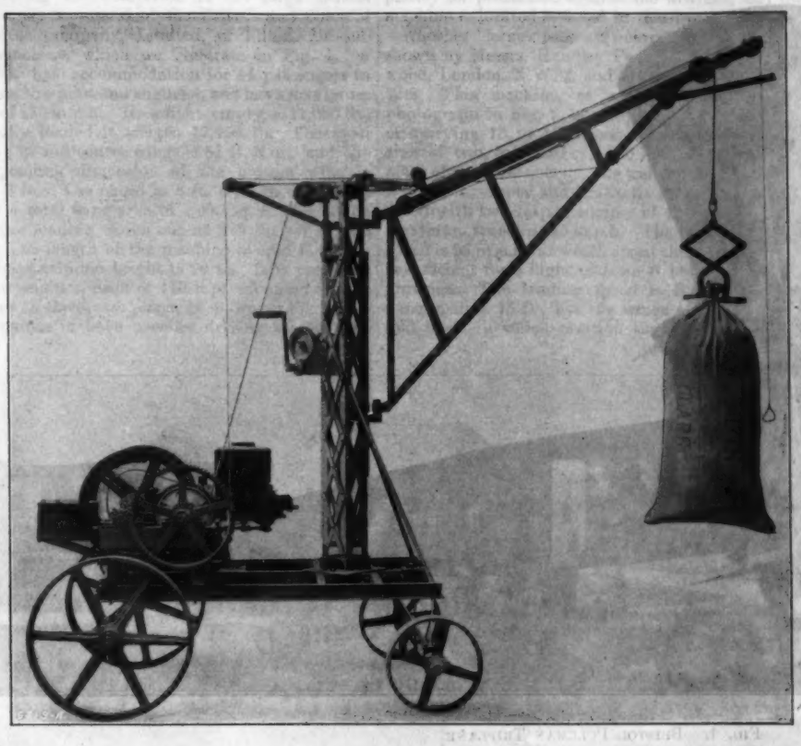


FIG. 39.

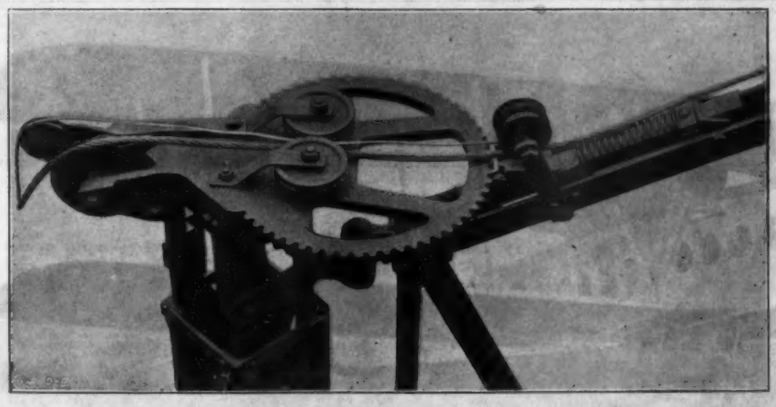


FIG. 40.

blocks, which are moulded blocks 6 in. deep, 11·5 in. long and either 6 in. or 8 in. in thickness. The special feature of these blocks is that they are pierced with large vertical holes arranged in such a manner that there is a free air circulation within the interior of a finished wall. Any straight line drawn through a wall of these blocks must traverse at least one air space, and it is claimed that the construction is not only light and strong, but eliminates all possibility of the walls "sweating" due to changes of temperature. The machine by which the blocks are made is illustrated in Figs. 24 to 38, on page 72. It consists essentially of a pair of cast-iron side frames carrying a fixed table upon which the stripping plate, which also forms the bottom of the mould, rests. This plate is marked *a* in Fig. 24. Hinged to the side frames near the ground are two vertical columns, connected together at the top by an adjustable beam. This beam carries on its underside a shaft, which, when rotated by means of the hand levers keyed to it, causes the descent of a crosshead, which slides on the columns as guides. Dies for pressing the concrete in the mould are bolted to the crosshead. The arrangement will be understood by reference to Figs. 24 and 25. When the moulds are being filled the whole of this gear can be swung back out of the way, until one of the side columns rests against the stop *b*, in Fig. 26, the weight of the gear being more or less counterbalanced by the spring *c*.

Through the lower part of the frame runs a horizontal shaft which can be rotated by the long hand lever shown at the right-hand side of the machine, and a pedal extension of this lever allows of the work being assisted by the foot of the operator. This lever is shown separately in Fig. 32. The shaft carries two pairs of cranks, the outer pair raise and lower the table *d*, which carries the mould-box, while the inner pair do the same to the table *e* which carries the cores for the air spaces. Reference to Figs. 24 and 25 will make the arrangement clear. In Figs. 34 to 37 various mould boxes, with the concrete blocks inside them, are illustrated. The mould-box in use is bolted to the underside of the table *d* and rests upon the loose stripping plate above-mentioned.

To use the machine the columns and head gear are swung back out of the way and concrete filled in the mould-box around the cores which project upwards into it from the table *e* on which they are carried. The columns are then brought into a vertical position and the upper dies pressed down on to the top of the concrete by means of the hand levers. The position of these is then as shown in Fig. 38, the connecting rods being on their dead centres. The operator then pulls forward the long side lever, assisting the work by means of the pedal, and the immediate effect of this is to raise the plate *d* with the mould-box, the concrete blocks being retained by the pressure of the top dies. As soon as the lost motion of the levers working the table *e* is taken up, this table begins to descend, pulling the cores downward out of the blocks. At the end of the stroke of the hand-lever, the concrete blocks remain standing on the stripping plate and free both from the mould and the cores. The upper dies are then released and the blocks removed. A pair of blocks are made at each operation. Fig. 36 shows the plan view of a pair of 6-in. wall blocks, and Fig. 37 a pair of corner blocks to suit. Figs. 34 and 35 give corresponding views of the wider blocks.

Some of the heaviest manual work on a farm consists in lifting sacks of corn on to wagons or into granaries, &c., and to avoid the demands which this makes upon men even of strong physique, Messrs. Arthur Clayden and Co., of the Retreat Works, Richmond, Surrey, have put on the market the portable power hoist illustrated in Fig. 39, annexed. This machine, which of course is serviceable for lifting loads of all kinds within its capacity, consists essentially of a light-wheeled platform carrying a jib crane with an oil engine and winch. The engine, which is of British manufacture, is of the hopper type and develops from 3 brake horse-power to 5 brake horse-power. It drives the winch by means of spur reduction gear. A friction clutch on the drum shaft engages or disengages the winch as required, and the same lever that operates the clutch, simultaneously operates a brake, and in fact controls both the raising and lowering of the load. The pillar of the jib crane is of lattice work, square in cross-section. It is built in two parts, the upper of which slides telescopically into the lower one so as to facilitate transportation and to provide for an adjustable height of the jib arm. A geared rack and pinion motion is fitted for the purpose of increasing or diminishing the height of the jib. When used for sack hoisting, a special gripping device is placed over the mouth of the sack, and a pull on the control cord at once raises the sack. When the cord is released the sack is held stationary wherever it may happen to be, and when the cord is pulled to its neutral position the sack is lowered by means of the brake. If the load is raised to its highest point it automatically throws out the clutch and puts the brake on the hoisting drum. The operation of the hoist is apparently as simple and safe as it could possibly be, and it is claimed that by its aid a boy can load up 40 sacks of wheat on to a wagon single-handed, in 10 minutes, whereas a strong man would require the best part of an hour to do the job by his physical strength.

The jib is arranged to swing round through a total arc of something like 270 degrees, so that it can pick up or deposit its load over a great range of position. When the sack is actually ascending or descending, however, the jib is automatically locked by the device shown in Fig. 40. The tension in the control rope, which must always exist under such circumstances, causes a small toothed dog to engage with the teeth on the fixed quadrant, and so to lock the jib to the standard. When the control rope is free, the dog is held out of engagement by the spiral spring seen in the illustration. The whole design of the apparatus is ingenious and mechanically sound, and the winch and engine can be readily detached and used for other purposes if desired.

AEROPLANES AT THE INTERNATIONAL AERO EXHIBITION.

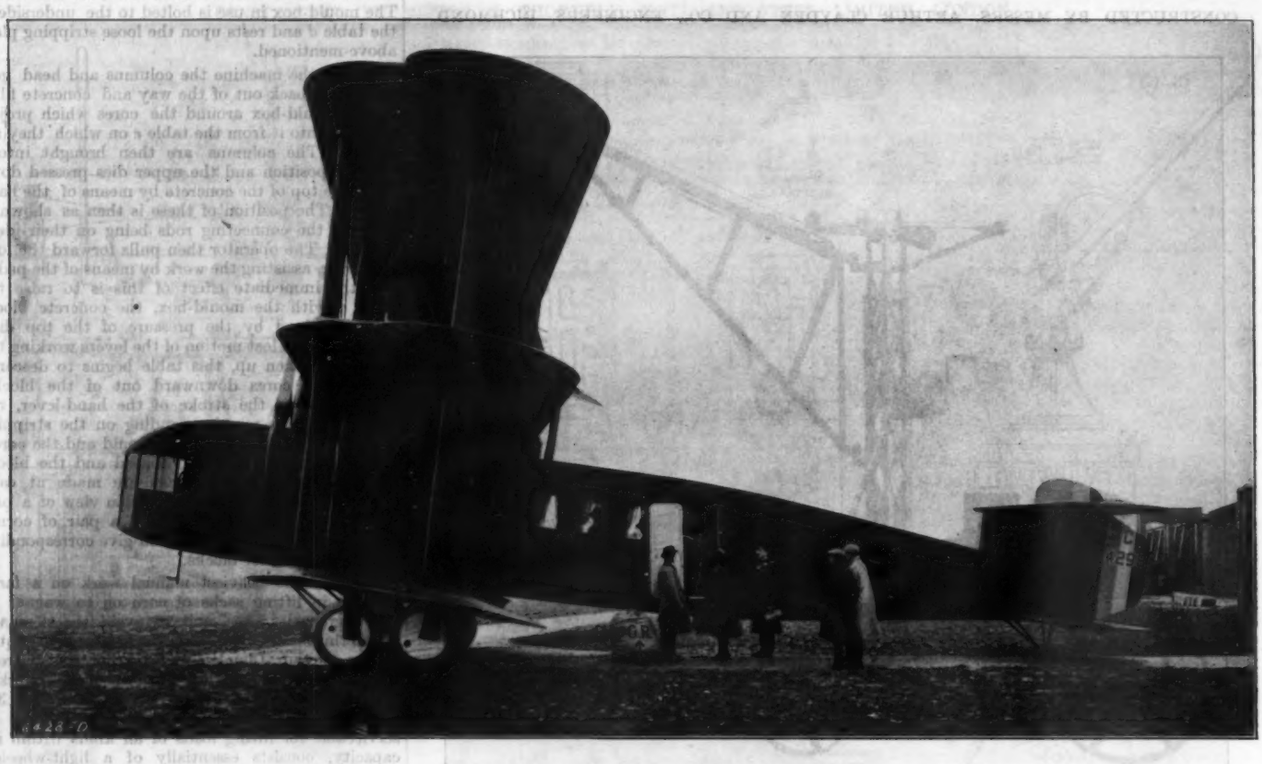


FIG. 1. BRISTOL PULLMAN TRIPLANE.

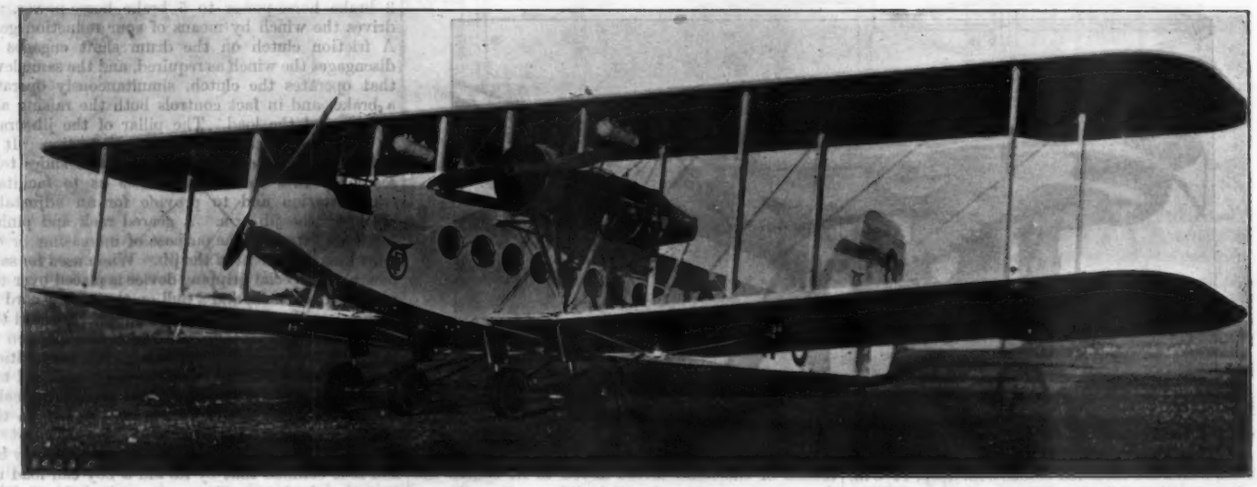


FIG. 2. HANDLEY PAGE BIPLANE, TYPE W. 8

THE INTERNATIONAL AERO EXHIBITION.

THE first International Aero Exhibition was held at Olympia in 1909 under the auspices of the Society of Motor Manufacturers and Traders, and similar functions were held annually, excepting in 1912, until March, 1914. The growth of the British aircraft industry during the war was so rapid and extensive that a separate body, the Society of British Aircraft Constructors, was formed, and the Sixth International Aero Exhibition, which opened on Friday last at Olympia, has been organised jointly by this society and the original Society of Motor Manufacturers and Traders. A joint Exhibition Committee has been set up and the exhibition organisation maintained by the Society of Motor Manufacturers for its annual motor and other exhibitions has been utilised. The long interval that has elapsed since the previous exhibition at Olympia, and the tremendous strides made in the aircraft industry in the meantime, invite comparisons between the two exhibitions, but although much material is available for such a comparison considerations of space compel us to proceed at once to our account of the exhibition now open.

Considering the stagnation at present existing in the industry the show is remarkably complete, and the exhibits indicate that our manufacturers generally are doing their utmost to secure in commercial aviation the lead held by this country in military aviation at the termination of the war. Large and small machines for the carriage of passengers and goods are shown in considerable numbers, and there are also a number of small single-seater machines for private users. Seaplanes are perhaps hardly as well represented as might be expected in an island country such as ours, but several makers showing land machines can fit these machines with floats if required. Airship exhibits are by no means numerous, but lighter-than-air craft, of course, does not lend itself particularly well to exhibition in a closed building. Airship builders are also less numerous than the constructors of the heavier-than-air machines. The exhibition

however, is fairly representative of the industry, and it gives the British public the first opportunity of seeing for itself what remarkable progress has been made in aviation in the course of the war.

The most striking exhibit which meets the eye on entering the exhibition is the large Bristol triplane on the stand of the British and Colonial Aeroplane Company, Limited, of Filton, Bristol. This machine, which we illustrate in Fig. 1, on page 74, has accommodation for 14 passengers in addition to a pilot and engineer, and has a maximum speed of 135 m.p.h. Its weight, empty, is 11,000 lb., and fully loaded it weighs 17,750 lb. The span of the top and centre wings is 81 ft. 8 in., and the corresponding dimension of the bottom wing is 78 ft. 3 in. The chord is 8 ft. 6 in. in each case, giving a total wing area of 1,905 sq. ft., for which the wing loading works out at 9·3 lb. per square foot. The length of the machine overall is 52 ft., and the maximum height is 20 ft. It is propelled by four engines, each of 410 h.p., mounted in two nacelles on the centre plane, as shown in Fig. 1, the two engines in both nacelles driving tractor and pusher screws respectively. The petrol capacity is 430 gallons, which is sufficient for 5 hours' flight at a cruising speed of 105 m.p.h., and, with this amount of petrol, the load carried in addition to the pilot and engineer would be 2,700 lb., though with fuel for 2½ hours a load of 4,000 lb. can be carried. The seats provided for passengers can easily be removed and the space available for carrying goods then amounts to 570 cub. ft. The machine has a landing speed of 55 m.p.h., and comes to rest in about 175 yards. It can "take off" in about the same distance after all four engines are opened out, but it has been found possible to take off with two engines only. The machine can climb to 5,000 ft. in 5 minutes and to 10,000 ft. in 12 minutes, while its maximum ceiling is 15,000 ft. The same firm also show a three-seater machine known as the Bristol Puma tourer, intended for high-speed cross-country flying. The makers claim that the high power, large tank capacity, strong construction and stability of this machine render it suitable for safe and comfortable flying in any weather, and it is also said to be capable of landing in, or rising from, very confined areas. It is fitted with a Siddeley Puma engine developing 246 h.p. at 1,400 r.p.m., and giving a speed of about 115 m.p.h. This machine has an overall length of 26 ft. 1 in. and the span of both wings is 39 ft. 5 in. The chord of both wings is 5 ft. 6 in., giving a total wing area of 405 sq. ft. The weight of the machine empty is 1,900 lb., while petrol, oil and water make up another 640 lb., and the additional load carried, including the pilot, amounts to 580 lb.; the total loaded weight is thus 3,120 lb. This machine can be provided with a *coupé* body in order to enclose the passengers and cargo completely for protection against the weather, and the machine exhibited is fitted in this way.

Another large passenger-carrying machine is shown by Messrs. Handley Page, Limited, Cricklewood, London, N.W. 2, and is known as their type W.8. This machine, of which we reproduce a photograph in Fig. 2, is a biplane, and is capable of carrying 15 to 18 passengers in addition to a crew of two, or a load of 3,240 lb. can be carried in place of the passengers. The weight of the machine is 6,400 lb. empty and 12,000 lb. fully loaded, and, fitted with two Napier engines of 450 h.p. each, its maximum speed is 115 m.p.h. The normal cruising speed is 95 m.p.h., at which speed the tank capacity is sufficient for a flight of from 6 hours to 7 hours duration. The landing speed is 50 m.p.h. The wing span is 75 ft., but the wings are arranged to fold back, in which position the maximum width of the machine is only 29 ft. When folded the total height is 17 ft. and the length overall is 61 ft.; these two dimensions are practically the same when the wings are extended for flying. As will be seen from our illustration, Fig. 2, the arrangement of the main planes is very similar to that adopted for the well-known V-1,500 bombing machines, that is a dihedral angle is employed on the lower plane only. The engines are carried on overhung frames, clearly shown in Fig. 2, which enable the propeller centres to be placed the necessary distance apart while keeping the distance between the wing hinges down to a minimum. The arrangement also enables the engines and petrol tanks to be removed by a direct lift, and the small distance between the engine centres has the additional advantage that the machine is more easy to control in the event of the failure of one engine.

The most interesting feature of Messrs. Vickers' exhibit is their Viking amphibious machine which we illustrate in Fig. 3, annexed, though they also show their Vimy commercial aeroplane. We have, however, previously illustrated and described the latter on page 736 of our one hundred and seventh volume, and also the bombing machine of which it is a development, on page 604 of the same volume, so that we do not propose to refer again to the commercial machine here. As will be seen from our illustration, the amphibious machine is a boat seaplane fitted with wheels for landing on, or taking off from, the ground, and the wheels are arranged so that they can be raised clear of the water when alighting on the sea. The machine is fitted with a cabin accommodating five persons, but, if desired, the seats can be removed, giving 76 cub. ft. of space for the carriage of goods. With one pilot weighing 180 lb., 1,000 lb. of useful cargo can be carried. Empty, the machine weighs 2,740 lb., while petrol, oil and reserve water make another 625 lb., so that with pilot and passengers, or goods, weighing 1,180 lb. together, the total weight of the machine amounts to 4,545 lb. It is propelled by a single Rolls-Royce Eagle engine giving 350 h.p. and driving a pusher screw which gives a maximum speed of 110 m.p.h. near the sea level. The climb to 6,000 ft. is made in 11 minutes, and at this height the maximum speed is 105 m.p.h. At full speed the range at 6,000 ft. is 395 miles, but by throttling down to 90 m.p.h. the range is increased to 440 miles. The main planes have a span of 46 ft. with a chord of 6 ft., so that their total area is 505 sq. ft., and the wing loading comes out at 9 lb. per square foot.; the load per horse-power is 13 lb.. The angle of incidence of the main planes is 5 deg., and there is a dihedral angle of 5 deg. on the bottom plane only. The overall length of the machine is 32 ft., and its height is 13 ft. The machine is certainly one of the most interesting in the exhibition, and it is obviously capable of a greater variety of work than either a simple seaplane or land-type machine. A number of scale models of the Vimy bomber and other machines constructed by Messrs. Vickers are on view at their stand, and among them is included one of the Valentia flying boat now under construction which will be capable of carrying a useful load of 2·3 tons. The wing floats of this machine are exhibited, and these convey some faint impression of its enormous proportions. Airship models, small tools, stampings, and other products of the firm are also shown.

FIG. 3. VICKERS' AMPHIBIOUS BOAT SEAPLANE.

The Fairey Aviation Company, Limited, of Hayes, Middlesex, and Hamble, Southampton, show a particularly interesting seaplane of the twin-float type, of which the special feature is the variable camber gear fitted to the wings. This machine is a two-seater biplane designed for fighting service, fitted with accommodation for a pilot and gunner and also carrying wireless and other signalling apparatus. The wing span is 40 ft., the chord 6 ft., the gap 5 ft. 6 in., the length overall 30 ft. and the height 12 ft. 6 in.; the wings, however, are arranged to fold backwards and slightly upwards, so as to clear the tail and the space required for stowage is greatly decreased by this

means. In appearance the machine is exceptionally squat and sturdy looking, and the floats are much larger in comparison with the wings than is usual in this type of machine. The reason for this is, of course, that the high lift coefficient due to the variable-camber device has enabled the wing area to be diminished. The variable camber is obtained by means of a flap hinged to the wing behind the rear spar, the flap being lowered when alighting, or taking-off, and raised when clear of the water to give a high flying speed. The tail is also adjusted automatically with the wing flaps, but the means by which this is accomplished are not disclosed. It has, however, been in use on British service machines for upwards of three years, and, we understand, has given entire satisfaction. It may be interesting to note that without the variable camber device the wing area would need to be increased by 60 per cent. Another special feature of the machine is the sectional system of construction adopted. The wings, engine mounting, and other parts are all attached to a central steel framework, from which they can be readily detached for repairs or for packing the machine for transport. It should also be mentioned that the pilot is provided with an adjustable seat, which he can raise himself in order to get a clear view over the plane for fighting. His normal position is such that, looking under the plane, he can see the floats, and is thus able to judge his height above the water when alighting. The use of a stabilising fin has been avoided by increasing the depth of the fuselage, and, by this means, a clear arc of fire to the rear is obtained from the gunner's cockpit.

Messrs. Short Brothers (Rochester and Bedford), Limited, of Rochester, Kent, also show a float-type seaplane with accommodation for a pilot and three passengers, but their most interesting production and in our view, the most important item in the whole exhibition, is the land machine entirely constructed of metal, made by the firm and exhibited on their stand. The machine is a single-seater, fitted with a Siddeley Puma engine of 260 h.p. and having a maximum speed of 120 m.p.h. The wing span is 39 ft. and the chord 5 ft. 3 in., giving a wing area of 368 sq. ft., and the weight empty amounts to 1,865 lb. Fuel and oil weigh 425 lb., pilot 180 lb., and, with 200 lb. of goods, the total weight of the machine amounts to 2,670 lb.; it can, however, carry 500 lb. of goods, with which the total weight would be 2,970 lb. The wing loading with the smaller load works out at 7·22 lb. per square foot, and the weight per horse-power to 10·27 lb. We give a general view of the machine in Fig. 4, on the present page, and annexed are illustrations showing details of the metal construction of the wings and fuselage. Fig. 5 shows the construction of the wings, the spars of which are of steel tubing having a tensile strength of 50 tons per square inch. The compression struts are also of steel, while the

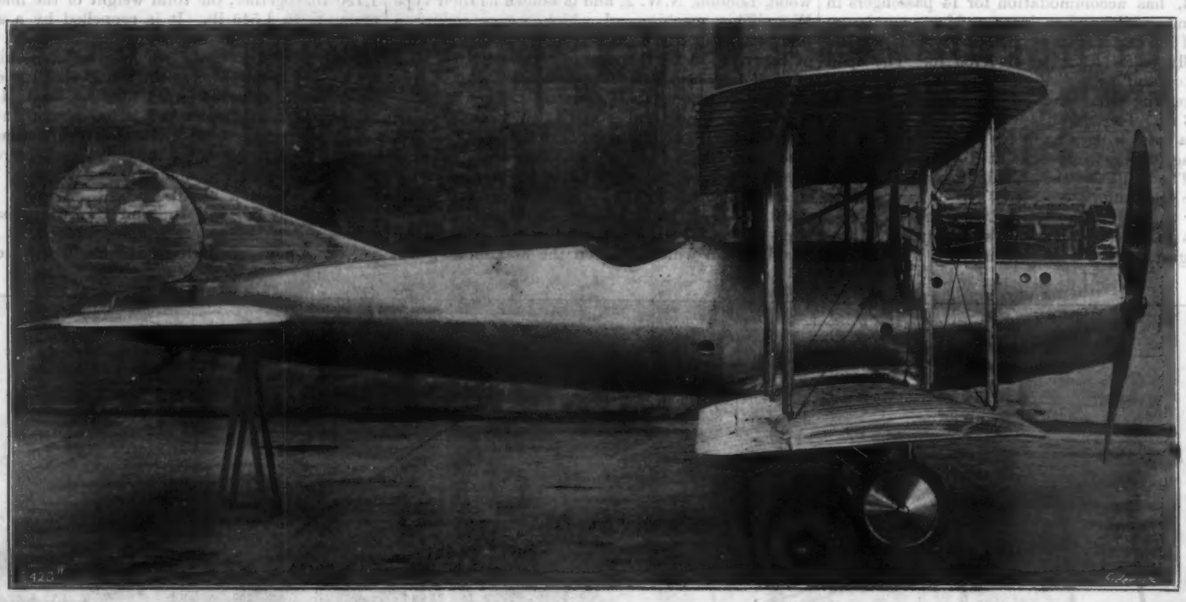


FIG. 4.

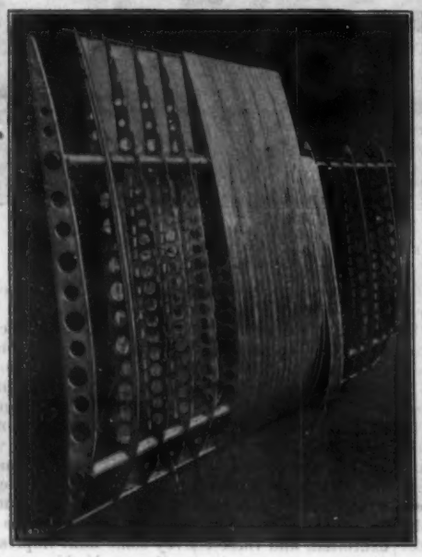


FIG. 5.

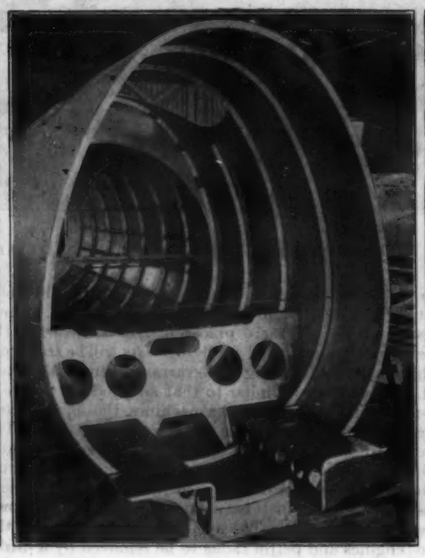


FIG. 6.

FIG. 7.

FIGS. 4 TO 7. ALL-METAL AEROPLANE BY MESSRS. SHORT BROTHERS.

internal bracing is of stranded cable. The ribs are of 24 S.W.G. Duralumin sheeting with flanged circular lightening holes as shown in the illustration, and the wing covering is actually of 26 S.W.G. aluminium sheets, although, in the ordinary way, the covering would be of 30 S.W.G. sheets. The covering sheets are slightly flanged and attached to the ribs by rivets, the joints being neatly covered by strips bent to a semi-circular section. The main struts are of steel tubing of stream-line section, and the external bracing is of stranded wire. The fuselage is of good stream-line form, as shown in the general view, Fig. 4, and is of egg-shaped section, as seen in Fig. 6. The outer shell is composed of Duralumin sheets, 22 S.W.G. in thickness, riveted together and stiffened longitudinally by strips of special section pressed from 24-gauge sheets and distinguishable in Fig. 6, which also shows the construction in way of the pilot's seat. Circumferential stiffening rings of ¾ in. by ¾ in. Duralumin angles, 18 gauge in thickness, are also visible in this illustration. The remaining Fig. 7 shows the method adopted for carrying the engine bearers, which are of steel tube, and this illustration also shows the fireproof bulkhead fitted behind the engine space. The tail plane, fin and rudder are constructed of steel tubular frames, Duralumin ribs, and aluminium covering in a manner similar to that adopted for the wings, and the undercarriage is of steel tubular construction throughout, with rubber shock absorbers and oil dashpot recoil cylinders. The machine is intended for mail carrying in any country, tropical or otherwise, and it will be obvious that the absence of all internal bracing from the fuselage gives ample space for the stowage of cargo of this type. The durability and fire-resisting properties of this all-metal construction are also important *desiderata* in commercial service, and Messrs. Short are to be congratulated in having produced what is, as far as we are aware, the first British machine in which the use of inflammable materials has been completely avoided. The question, of course, arises as to how the first cost of an all-metal machine would compare with one of the ordinary construction, and to this Messrs. Short reply that, when produced in quantity, the cost of the former type would be little, if any, higher than that of the latter. Messrs. Short also show a working model of a method they have devised for landing seaplanes. We regret that pressure on our space does not permit us to deal fully with the arrangement on the present occasion, but we may mention that it comprises two rectangular pontoons mounted on slipways and having holes in the bottom through which the water is driven by compressed air when it is desired to raise the pontoons over which a seaplane has been brought in order to examine the floats or hull. The pontoons automatically move up or down the slipways as the tide rises or falls, and are prevented from moving laterally by bracing to an undercarriage running on rails. Another set of rails is also provided between the two pontoons, and a machine can be hauled up on a truck on these rails in the ordinary way.

Fig. 8, subjoined, illustrates the Centaur 4B. float type seaplane made by the Central Aircraft Company, of 179, High-road, Kilburn, London, N.W. 6, and shown at their stand. The machine carries two passengers in addition to the pilot, and is fitted with a 100-h.p. British Anzani air-cooled engine giving a speed range of 40 m.p.h. to 75 m.p.h. The petrol consumption is 8 gallons per hour and the oil consumption ¼ gallon per hour; the tank capacity is sufficient for a flight duration of 3 hours. The wings have a span of 39 ft. 1 in., with an area of 380 sq. ft., so that, as the total weight of the machine is 1,900 lb., the load per square foot of wing surface amounts to 4·94 lb., and the load per horse-power 19 lb. Unladen the machine weighs 1,230 lb. so that the useful load is 670 lb., of which 500 lb. may be in the form of goods if no passengers are carried. The machine has an overall length of 27 ft. 1 in., and it should also be mentioned that means are provided to enable the pilot to swing the propeller for starting the engine without leaving his cockpit. This is, of course, a particularly important consideration in a seaplane, as the operation of swinging the propeller while standing on the floats is attended with some risk. A small water rudder, attached to the stem of the tail float, is also provided to facilitate the steering of the machine when "taxying" on the water.

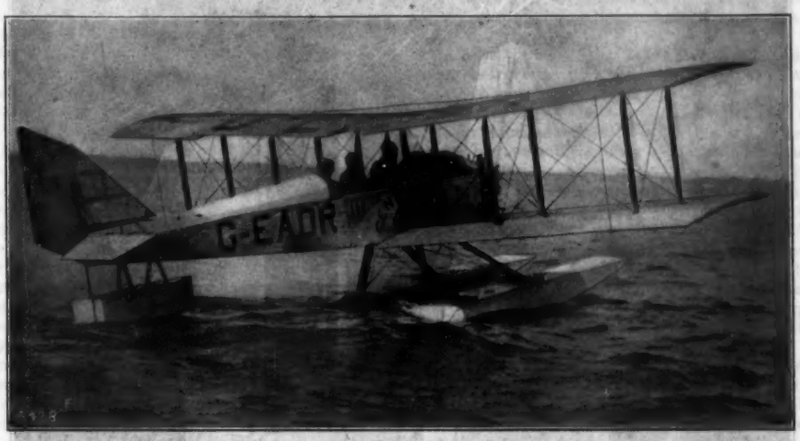


FIG. 8. CENTAUR THREE-SEATER FLOAT SEAPLANE.

Two boat seaplanes are shown on the stand of the Supermarine Aviation Works, Limited, of Woolston, Southampton, who specialise in aircraft of this type. One of these, designated the "Sea King," is a single-seater fighting scout armed with a machine gun and three trays of ammunition, fitted with a 160-h.p. Beardmore engine and having a speed range of from 51 knots to 96 knots. The machine, equipped as stated, can climb to 10,000 ft. in 20 minutes, but it can be made to carry two, 50-lb. bombs in addition, with a slight reduction in the rate of climb. A more interesting exhibit is, however, the firm's "Channel Type" commercial flying boat, which is designed for carrying three passengers, or 540 lb. of goods, in addition to the pilot. This machine is also fitted with a 160-h.p. Beardmore engine giving a speed range, near the sea level, of from 46 knots to 70 knots, and the petrol capacity is 45 gallons, which is sufficient for a flight of 240 to 250 sea miles. The general appearance of the machine is illustrated by the half-tone engraving, Fig. 10, on page 82, while the arrangement of the main parts is shown in the side elevation reproduced in Fig. 11. Particular attention is paid to the design of the hull of these machines in order to make them seaworthy. The hull proper, which has a length of 30 ft., is of practically circular section and is of planked construction similar to that employed for motor boats. It is covered with fabric, and the steps are built on separately so as to form a double bottom. The pilot's cockpit is situated immediately in front of the wings, while forward of this is a cockpit accommodating two passengers, the other passenger sitting in a third cockpit near the nose of the machine. The span of the upper main plane is 50 ft. 5 in., and that of the lower plane is 39 ft. 7 in. Both have a chord of 5 ft. 6 in., so that the total wing area is 453 sq. ft. The angle of incidence of both planes is 4 deg., and both have a dihedral angle of 4 deg. The wings, it should be mentioned, are arranged to fold forward, and in this condition the maximum width of the machine is 14 ft. 1 in. An interesting feature of the machine is the design of the empennage, which is shown in side elevation in Fig. 11. From this it will be noticed that the tail plane is of the biplane type, the planes being of aerofoil section and arranged to oppose each other. The upper plane, which is inverted, as shown in our illustration, and placed in the slip stream of the propeller, thus produces a clockwise pitching moment, and this balances the anti-clockwise pitching moment due to the thrust. The result of this arrangement is that the longitudinal stability of the machine is not affected by shutting off the engine; the complete tail is neutral when the engine is cut-off. The water rudder, which is connected with the air rudder, and is used for steering the machine when taxying on the water, is also shown in Fig. 11. The machine is very convenient for school work, and is so employed in the Norwegian Navy, a duplicate set of controls being fitted in the cockpit situated in front of the pilot's cockpit. The controls, it may be mentioned, are all designed with a three-point suspension from the hull, and they can be disconnected from the control surfaces and removed completely in a few minutes. The three-point suspension also prevents the main control bearings from binding owing to the working of the hull. There are several other interesting features in the design of this machine which indicate that every effort has been made to secure reliability in service. Want of space prevents us from referring to all of these, but we may mention that all controls are in duplicate and all the main components can be quickly and easily detached, if necessary, for repairs, or in dismantling the machine. For instance, the whole of the main wing structure, including the engine mounting, can be removed and replaced in 2 hours. The method of securing the radiator is also interesting. It is suspended from the front spar of the main plane, and the drag is taken back to the engine by universal joints while lateral stresses are taken by wires. The arrangement is such that engine vibration is not transmitted to the radiator, and consequently the liability to leakage is considerably reduced. In addition to the school work in the Norwegian Navy above referred to, the machine is used for mail carrying and commercial work in Norway, and also in the Bermudas and the West Indies. If desired, the front cockpits can be provided with a cover to form a closed cabin, and the machine can also be fitted with landing wheels to render it amphibious by reducing its passenger carrying capacity to two.

As previously mentioned airships are not particularly well represented at the exhibition, but there is an interesting airship exhibit at the stand of Messrs. W. Beardmore and Co., Limited, of Dalmuir. This is a sample passenger cabin constructed of Duralumin and designed for H.M. rigid airship R.36 now approaching completion at the Inchinnan Works of the firm. As will be seen from the engraving Fig. 9, on page 78, there are two cabins on each side of a central gangway and each cabin provides accommodation for two passengers with a sleeping berth for each. Under the berths are folding tables and wickerwork chairs which can still be used when the berths are let down ready for use. Large windows which give a good view in all directions will also be noticed on the left of the illustration. The whole passenger accommodation is hung below the main framework of the ship and is completely isolated from the engine cars so that there is no possibility of hydrogen or petrol fumes reaching the passengers. The complete scheme provides accommodation for 52 passengers and extends along the underside of the hull for the greater part of the length of the airship. Galleys and lavatories

are arranged amidships dividing the cabins into two groups, and the former are of sufficient capacity to supply food for all the passengers simultaneously. The cars have a double skin to insulate them from the outer air and will be heated by exhaust gas from the engines. Ventilation can easily be supplied by opening the windows or louvres, and the cabins will, of course, be lighted electrically.

The only aeroplane on Messrs. Beardmore's stand at the time of our visit, was a two-seater sporting and touring model known as the W.B.2. In general the machine is similar to the firm's fighting, reconnaissance and long distance patrol machine of the same designation, a number of which were supplied to the Royal Air Force, and it is capable of carrying one passenger, or 170 lb. of mails in addition to the pilot. When fitted with the 160-h.p. Beardmore engine the speed is 107 m.p.h. near the ground and 97 m.p.h. at 10,000 ft., which height is reached in 25 minutes; the landing speed is 55 m.p.h. The petrol consumption is 11·6 gallons per hour and the oil consumption 0·58 gallon per hour, at which consumption the tank capacities are sufficient for a flight of 415 miles. The weight of the machine fully loaded is 2,516 lb., so that the loading per horse power comes out at 15·7 lb. The main planes, which are of R.A.F. 15 section, have a span of 34 ft. 10 in. with a chord of 5 ft. 6 in. giving a total wing area of 354 sq. ft.; the wing loading is thus 7·1 lb. per square foot. They have a positive stagger of 2 ft., and are set at an angle of incidence of 1½ deg.; the dihedral angle is also 1½ deg. Generally speaking the machine follows the usually accepted type of construction, but it may be mentioned that provision is made for adjusting the incidence of the tail plane in flight, the range of adjustment being from 0 deg. to 5 deg. The overall length of the machine is 27 ft. 7 in. and the maximum height 10 ft. 11 in. We understand that it will shortly be employed for the carriage of passengers, goods and mails between Glasgow and London. Messrs. Beardmore also exhibit models of H.M. airship R.34 and of H.M. seaplane carrier "Argus," both of which were built by the firm.

Except for the large Bristol machine, above referred to, the only triplane exhibited is shown by Messrs. A. V. Roe and Co., Limited, Newton Heath, Manchester, and has been specially designed for the economical transport of passengers and goods. The fuselage contains a cabin with accommodation for four passengers, who sit two a side facing each other, as in a railway carriage, but, if mails or goods are to be carried, the seats can be removed, giving a space of 113 cub. ft. for this purpose. The pilot's cockpit is situated behind the cabin in such a position that he can obtain an exceptionally clear view of the ground for landing or taking off. The machine is fitted with a 240-h.p. Siddeley Puma engine, which gives it a speed of 100 m.p.h. near the ground and 94½ m.p.h. at 5,000 ft., at which level the flying range is 574 miles; the climb to 5,000 ft. takes 7·6 minutes. Unladen the machine weighs 2,080 lb., and a useful load of 1,206 lb. brings the total flying weight to 3,286 lb. The overall length of the machine is 29 ft. 10 in. and the maximum height 14 ft. 5 in. All the wings have the same span, viz., 37 ft. and the chord, in each case, is 4 ft. 9½ in. The wing area is thus 498 sq. ft., and the wing loading comes out at 6·6 lb. per square foot. The angle of incidence of each wing is 4 deg. and all have the same dihedral angle of 2½ deg. Ailerons are fitted on each wing and they are balanced by means of a small auxiliary aerofoil attached by means of brackets to each of the ailerons on the middle wing. The tail plane is of the monoplane type and the empennage includes a vertical fin; the rudder is balanced aerodynamically. An important feature in the design of this machine is that many of the parts, including the wings, empennage, chassis and tail skid, are identical with those employed in the firm's well-known standard training machine, of which large numbers were constructed during the war. Arrangements are, therefore, in existence for the rapid and economical production of these parts, so that repairs and replacements can be quickly and cheaply effected. This is obviously worthy of consideration by concerns proposing to operate these machines commercially. Messrs. Roe also exhibit a three-seater tourist machine, which is a development of their standard school machine and retains the features of strength, safety and easy control for which the latter is justly noted. They also show a light single-seater machine known as the "Avro Baby" and intended for use by the private owner. It is fitted with a 35 h.p. to 40 h.p. Green engine and has a speed of 80 m.p.h. near the ground. At a cruising speed of 60 m.p.h. the machine can travel 30 miles to the gallon of petrol, which compares quite favourably with the performance of a light car. The machine, it may be mentioned, is that in which Mr. Hinckliu recently made a non-stop flight from Croydon to Turin, a distance of about 650 miles, in 9½ hours, with a consumption of about 20 gallons of petrol. This was certainly a remarkable performance for such a small machine.

The smallest machine at the exhibition, and we believe the smallest constructed so far, is shown on the stand of the British Aerial Transport Company, Limited, 38, Conduit-street, London, W. 1, and is known as the "B.A.T. Crow." It may, in fact, be said to have the same relationship to an ordinary aeroplane that a motor cycle has to a touring car. The "Crow" is a monoplane with a wing span of 19 ft., and the fuselage consists of two wooden spars of box section tapering towards the tail. There are no bracing wires and the pilot is seated under the plane in a small nacelle mounted on a comparatively large central skid between the two landing wheels. It is propelled, at about 75 m.p.h., by a 40 h.p. A.B.C. "Gnat" air-cooled engine, with twin opposed cylinders, mounted near the leading edge of the plane. A single tank holds 5 gallons of petrol and half a gallon of lubricating oil, which is sufficient for a flight of nearly two hours duration covering a distance of about 150 miles. The overall length of the machine is 14 ft., and its weight is given as 220 lb.; it can be easily dismantled for storage. A small single-seater fighting machine, called the "Bantam," is also shown by the firm. The fuselage is of monocoque construction which has the advantages that it is but little affected by enemy fire and is also easily repaired. The machine is fitted with a 200 h.p. A.B.C. "Wasp" engine, and, in a recent test at Martlesham Heath, it was found to have a speed of 146 m.p.h. at 10,000 ft. The wing span is 25 ft. and the weight, fully loaded, is 1,618 lb. For carrying goods, mails or passengers the firm build a useful machine known as the "Commercial Mark I," which is capable of carrying a paying load of 1,000 lb., with sufficient fuel for a flight of 660 miles, at a cruising speed of 110 m.p.h. A Rolls-Royce Eagle VIII engine, developing 350 h.p., is fitted. The machine exhibited is provided with a cabin in the fuselage accommodating four passengers, and the pilot is situated in an open cockpit aft of the cabin. Considering the overall dimensions of the machine, which has a span of 46 ft. and a fuselage 35 ft. in length, the cabin is exceptionally roomy, its dimensions being 8 ft. long, 6 ft. high and 3 ft. 3 in. wide; there are no internal cross bracings to interfere with the comfort of the passengers. The empennage is of the usual design but it should be mentioned that the incidence of the tail plane can be adjusted in flight to compensate for any variation in balance which might be caused by alterations in the quantity or disposition of the load. The landing chassis is also of special design comprising elastic and Oleo shock absorbers, and with the low landing speed of 45 m.p.h., it is claimed that safe landings can be made under the worst possible conditions.

FIG. 9. CABIN FOR RIGID AIRSHIP R 36.

The Blackburn Aeroplane and Motor Company, Limited, of Olympia, Leeds, show their latest model of a torpedo-carrying ship aeroplane for Government service. Unfortunately, official permission to exhibit this machine was obtained only on the condition that some of the special equipment, notably the torpedo gear, was omitted. The performance, however, which we shall refer to later, is high for a ship aeroplane, subjected as it must be to rigid limits of speed for getting off and landing. An interesting feature of the design, which has been adopted in order to reduce the cost of upkeep, is that the whole of the central unit, including the engine mountings, centre part of fuselage, centre section of wings, and undercarriage, is formed of a steel framework, which requires practically no truing up. Special attention has also been given to rendering the machine fireproof. For this purpose a fireproof bulkhead has been fitted behind the engine installation, and the petrol tanks are of the self-sealing type. Flotation bags are provided to give the buoyancy necessary in the event of a forced descent on to the sea, in which circumstance the landing wheels can be dropped off by the pilot. To facilitate stowage on board ship

the wings can be folded back, and the makers claim that the arrangement adopted is the first to allow the folding of staggered planes. Stagger is, of course, desirable for aerodynamic reasons, and, more particularly, because it considerably improves the pilot's view. The machine is fitted with a 450-h.p. Napier engine, and its weight, fully loaded with fuel for a flight of 4 hours' duration at full power, is 6,000 lb. The useful load, which includes the crew, but not the fuel, is 1,975 lb. The wing span is 48 ft. 6 in., but, with the wings folded, the width of the machine is reduced to 17 ft. 6 in. The wing area is 720 sq. ft., which gives a wing loading of 8·3 lb. per square foot, and the loading per horse-power is 13·3 lb. The overall length of the machine is 35 ft. 6 in., and its maximum height is 12 ft. The full speed is 98 knots, and the landing speed 43 knots. It can take off at a speed of 40 knots, the run necessary being only 40 yards in a 20-knot wind. The service ceiling is 15,000 ft. and the rate of climb is given as 850 ft. per minute. The firm also exhibit a model of one of their well-known "Kangaroo" aeroplanes converted for passenger carrying, and having a cabin accommodating nine passengers.

Three interesting machines are shown at the stand of Messrs. Martinsyde, Limited, of Maybury Hill, Woking, Surrey. The most striking of these is perhaps a small single-seater racing machine fitted with a 300-h.p. Hispano-Suiza engine and holding, we believe, the British speed record of 161·4 m.p.h. This speed was obtained for a distance of 1 km. during the first trials of the machine in March last, and was certified by the Royal Aero Club. The wing span of this machine is 20 ft. 2 in., the length overall 19 ft. 3 in., and the maximum height 7 ft. 3 in. The weight fully loaded is 2,025 lb., so that the load per horse-power is 6·7 lb. and the wing loading is given as 13·8 lb. A more useful type of machine is, however, the firm's F.4 A. two-seater, which is also exhibited, and is intended for sporting or touring purposes, or for high-speed mail-carrying or commercial services. The machine shown is fitted with dual control for instructional purposes and would be used to accustom pupils to the handling of a high-speed machine. In general the construction is similar to that of the firm's well-known "Buzzard" fighting scout, which came into considerable prominence in the later period of the war. The machine on the stand has one of the wings left uncovered to show the internal construction, and an inspection of this will show that the spars are built up of three laminations and that the fittings which take the struts and flying wires fit completely round the spar, which is only pierced through its neutral axis. The interplane struts are fitted by means of metal shoes dropped over a Duralumin block on the main spar fitting. The wing span is 32 ft. 9 in., the length overall 25 ft. 6 in., and the height (without the airscrew) is 8 ft. 10 in. A 300-h.p. Hispano-Suiza engine is fitted, and this gives a maximum speed of 142 m.p.h. The cruising speed is, however, 115 m.p.h. and the machine lands at the low speed of 44 m.p.h. Fully loaded, the weight is 2,300 lb., and the load per square foot of wing area is 7 lb.; the weight per horse power is about 7¼ lb. The tank capacity is 36 gallons of petrol, 4 gallons of oil and 10 gallons of water, which is sufficient for a flight lasting 2½ hours, or a journey of 295 miles. Another machine exhibited, and known as the "A" type, Mark II, has been designed to provide an aeroplane for commercial service at a low capital cost, and with light maintenance charges. It has accommodation for four passengers and a small amount of hand luggage, in addition to the pilot. The passengers sit facing forward, and have a clear view of the country over which they are passing, and the cabin is arranged so that it can be used either open or closed. This machine, like the two previously referred to, is fitted with 300-h.p. Hispano-Suiza engine, and has a cruising speed of 100 m.p.h., with a maximum speed of 115 m.p.h.; the landing speed is 40 m.p.h. The wing span in this case, is 43 ft. 4 in., the length, overall 29 ft. 1½ in., and the height, without the airscrew, 10 ft. 6 in. The weight, with full load, amounts to 4,000 lb., which is equal to 7½ lb. per square foot of wing area, and 13·3 lb. per horse power. The tank capacity is sufficient for a flight lasting 5 hours, in which 500 miles would be covered. Floats and a float undercarriage are also exhibited in connection with this machine for converting it into a seaplane, and some examples of Martinsyde airscrews are included in the exhibit.

Most of the smaller passenger-carrying machines seem to have been designed for the accommodation of four passengers in addition to the pilot, but in the case of the Westland Limousine exhibited by the Westland Aircraft Works (a branch of Messrs. Petters, Limited) of Yeovil, the space generally occupied by one passenger is utilised for the stowage of mails. This machine, a photograph is reproduced in Fig. 12, on page 82, carries three passengers, in addition to the pilot, and has two compartments in the front part of the cabin in which mail bags can be placed and sealed up. The pilot sits beside one of the passengers at a slightly higher level, so that communication between pilot and passengers is direct. Particular attention has been paid to the ventilation of the cabin for which purpose a shutter is provided on top and the air enters the cabin through a diffuser box with gauze-covered outlets. The various components of the machine are all attached to the central cabin portion in such a manner that they can be easily and quickly removed and replaced. The wings, engine mountings, rear portion of fuselage, and undercarriage can all be dealt with in this way. Special care has also been taken to render the machine as far as possible fireproof. The petrol tanks, for instance, are suspended from the lower wing, well away from the fuselage, as shown in our illustration, and all petrol connections are kept outside the cabin. Although only a minor point, it is perhaps worth mentioning that the landing wheels are fitted with Stauffer lubricators, which we did not notice on any other machine. The machine, fully loaded, weighs 3,800 lb., of which 680 lb is useful load. The span of both wings is 38 ft. 2 in. and the chord, in both cases, is 6 ft. 3 in. The wing area is thus 435 sq. ft., and the loading comes out at 8·75 lb. per square foot. The wings are set at an incidence of 2 deg. with a positive stagger of 12 in. and have a dihedral angle of 2½ deg. The engine fitted is a 300-h.p. Hispano-Suiza and the maximum speed is 115 m.p.h. The cruising speed would be about 90 m.p.h., and the landing speed with full load 55 m.p.h. A height of 5,000 ft. is reached in 8 minutes and the absolute ceiling in 15,000 ft. The petrol capacity is 64 gallons, and as about 6 miles are covered per gallon, the range would be 384 miles. We understand that the machine will be used for the carriage of mails between London and Paris for a number of banks.

The Sopwith Aviation and Engineering Company, Limited, of Canbury Park-road, Kingston-on-Thames, show three machines designated, respectively, as the "Antelope," "Gnu" and "Dove." The former carries two passengers in a closed cabin and a pilot in the usual cockpit. It is fitted with a 180-h.p. Viper Hispano-Suiza engine giving a maximum speed of 100 m.p.h. and a cruising speed of 85 m.p.h. Petrol is carried for a 4-hour flight at full speed. This machine has a wing span of 46 ft. 6 in., a length of 30 ft. 6 in., and is 11 ft. high. The "Gnu" has the same passenger accommodation, but is a rather smaller and faster machine, having a maximum speed of 110 m.p.h.; the cruising speed is, however, 80 m.p.h. or slightly lower than that of the "Antelope." A 110 h.p. Le Rhone engine is fitted on the "Gnu" and the petrol capacity is sufficient for a flight of 220 miles at full speed, or 300 miles at cruising speed. The main dimensions are: wing span 38 ft., length overall 25 ft. 6 in., and height 10 ft. The third machine is a fast two-seater aeroplane designed on similar lines to the Sopwith "Pup," which gave an extremely good account of itself during the war. It is intended for touring or sporting use, and can easily be adapted for use as a training machine for pilots if desired. The engine fitted is the 80-h.p. Le Rhone, giving a speed range from 40 m.p.h. to 100 m.p.h. Its weight fully loaded is 1,430 lb. and with this load it can climb to 5,000 ft. in 7½ minutes. The petrol capacity is sufficient for 200 miles at full speed or for 250 miles with the engine throttled down. The span of the machine is 25 ft., the overall length 19 ft. 6 in., and the height 9 ft. 6 in.

In our view the most interesting of the small single-seater machines exhibited is the Austin "Whippet" made by the Austin Motor Company, Limited, of Longbridge Works, Northfield, Birmingham, and shown, both complete and in skeleton form, on the stand of this firm. The special feature in the design of this machine is the use of steel tubing in place of bracing wires. The fuselage, for instance, is constructed entirely of steel tubing, and the usual lift wires for the wing structure are replaced by diagonal steel tubes of stream-line section; the interplane struts are also composed of stream-line tubes. Internally the wings are of timber construction with steel tube compression members, and they are arranged to fold back along the body in which position they are automatically locked and supported by tubes attached to the fuselage. In most other respects the design of the machine follows the usual practice but it may be mentioned that the tail-plane can be adjusted on the ground to suit pilots of different weights. The span of the main planes is 21 ft. 6 in. when extended, but, when folded back, the extreme width is only 8 ft. The machine has a length of 16 ft. 3 in. overall and is 7 ft. 6 in. high. It is fitted with an Anzani six-cylinder radial engine developing 45 h.p. to 50 h.p., which gives a speed of 90 m.p.h. to 95 m.p.h. near the ground, and 80 m.p.h. at 8,000 ft. The machine has a low landing speed of about 35 m.p.h., and a good climb, reaching 5,000 ft. in 9 minutes. Empty the machine weighs 600 lb., and, with a pilot and sufficient oil and petrol for a flight of 2 hours duration, the total weight is 810 lb. The petrol required for a two hours' flight, it may be added, is 6¼ gallons and the oil consumption in the same period would be 2 gallons. Generally the machine appears to be of particularly sound design and construction and to be well suited to the needs of the private user.

The one other machine which now remains to be referred to was entered by M. H. Potez, of Auber-villiers, near Paris, but, at the time of our visit, the machine had not arrived, the weather having prevented it from flying from France. We under-stand, however, that it is a two-seater machine in which the passenger sits almost exactly over the centre of gravity, so that it can fly equally well with or without a passenger. There are several peculiarities in the design, the undercarriage, for example, being fitted with four wheels, and the engine being placed with its crankshaft vertical and driving a two-bladed tractor screw through bevel gearing. The engine, which is of M. Potez's own design, is of the four-cylinder, air-cooled, motor-car type, and it is mounted on the front of the fuselage with the cylinder heads forward in the slip stream of the propeller. The cylinders are 100 mm. in diameter, the piston stroke is 120 mm., while the speed of the crankshaft is 2,200 revolutions per minute; the bevel gear, however, has a ratio of 2 : 1 so that the propeller runs at half the engine speed. The petrol consumption is given as 12 litres (2·65 gallons) per hour. The span of the upper plane is 8 metres (26 ft. 3 in.) and that of the lower plane 6·83 m. (22 ft. 5 in.). Unloaded the machine weighs 240 kg. (529 lb.) and with a useful load of 160 kg. (353 lb.) and fuel and oil for a flight of three hours duration (40 kg. = 88 lb.) the weight in running order amounts to 440 kg. (970 lb.). The wing loading is given as 22 kg. per square metre (4·51 lb. per square foot), and we understand that a factor of safety of 7 has been used throughout in the design. It may also be added that the wings are constructed internally of Duralumin, though they are covered with fabric in the usual way. Aluminium has also been employed in the construction of the engine in order to reduce weight.

(To be continued.)

RECORDS AT THE EDGAR THOMSON WORKS.—Some records for production of pig-iron and steel were made recently at the Edgar Thomson blast furnaces and steel works of the Carnegie Steel Company at Bessemer, Pa., says *The Iron Age*, New York. The Edgar Thomson blast furnace "C," for the week ending June 11, made 3,535 gross tons of iron. On Wednesday, June 9, the new No. 2 finishing mill of Edgar Thomson rolled 1,803 tons of standard section rails, and for the week ending June 11, this mill rolled a total of 8,213 tons of rails. No. 2 mill is equipped to roll either billets, sheet bars or rails, and the above is the largest tonnage of rails it has rolled in any one week since it was built.

CO-ORDINATION OF TECHNICAL AND SCIENTIFIC PUBLICATIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—The multiplication of societies and the great activity in all departments of science and engineering have given rise to an ever-increasing volume of publications containing information, often of interest and sometimes of great value, to those engaged in occupations on which they have a bearing. The difficulty of keeping track of all that is written on a given subject is patent to all, and on many occasions attention has been called to it publicly. Attempts are made to deal with the matter by the publication of abstracts by various Institutions, notably by the Institution of Civil Engineers and the Institution of Electrical Engineers, the latter in conjunction with the Physical Society, while other useful efforts in the same direction are due to private enterprise. Such efforts, valuable as they are, necessarily relate only to certain more or less restricted fields of knowledge, and considerable difference of opinion exists as to whether these abstracts should be full or very brief, or even whether they should comprise much more than the title of the paper abstracted.

In 1918 a conference was called by the Faraday Society under the chairmanship of Sir Robert Hadfield, when this question was debated at some length. The desirability of securing uniformity among the publications of different Institutions was pointed out and suggestions were made for the interchange of papers. Were such uniformity practicable a great boon would be conferred on readers because the great diversity in size, shape and arrangement of volumes renders it extremely inconvenient to assemble papers relating to a given subject. Any chance of uniformity is, however, very remote, and there is no likelihood of attaining agreement within a reasonable period. The nature of the matter to be published varies over a wide range, and a form that may be convenient for papers that have few or simple illustrations may be quite unsuitable for one dealing with engineering works of which elaborate drawings are given.

Recognising the impracticability of securing uniformity it has occurred to the writer that much might be done to ameliorate the present condition of things if every Institution and Society were, as a matter of routine, to publish a fairly full abstract of every paper printed in its ordinary Proceedings, such abstracts to be strictly uniform for all Institutions in regard to size of page and width of margin; the type might be uniform with varying number of pages, or the type might vary with uniform number of pages, or both might vary. The paper, while not being strictly uniform in quality, should be similar for all abstracts, especially in regard to thickness. An appropriate size to adopt would be that settled on after much deliberation by the British Engineering Standards Association for their standard specifications. This is exactly the same as that of the Institution of Civil Engineers' abstracts, and there should be no difficulty in reducing the size of page of the abstracts published jointly by the Institution of Electrical Engineers and the Physical Society to the same dimensions.

Were this suggestion carried out a number of advantages would ensue:—

1. In the first place any individual could collect full abstracts of all the papers on a given subject that interested him and bind them together, so securing a comprehensive and concise presentment of the present state of knowledge of the subject with the necessary data to enable reference to be made if desired to each paper *in extenso* in the ordinary Proceedings of the body before whom it is read.

2. The abstracts made would in every case be prepared by the author of the paper abstracted, thus securing accuracy and ensuring that a proper balance between the different parts of the paper was preserved.

3. The abstract being published either at the same time as the original paper, or even in many instances substantially earlier, the information would be available much sooner than now; often under existing conditions it is months after publication of the original paper that the abstract is published.

4. The expense of printing would be so subdivided among the various bodies that no one of them would feel the additional cost. Each individual author would prepare the abstract of his own paper free of charge as part and parcel of the work of writing the paper and the cost of printing would be inappreciable. Moreover, it is suggested that a charge be made by each Institution for all abstracts other than those required for use at the meeting at which the paper was read. This charge might with advantage cover the whole cost of production of the abstract.

Incidentally the compulsory preparation of a proper abstract would greatly improve the proceedings at ordinary meetings; the reading of papers in abstract or, better still, taking them as read instead of inflicting the paper *in extenso* on the audience is coming into increasing favour. In order that a paper may be adequately discussed it must be carefully studied beforehand by the speakers, and the whole time of a meeting is all too short for the proper discussion of a good paper.

If a scheme on the lines suggested were to come into being and the leading Institutions and Societies would bind themselves to adhere to it, the need for any other abstract of papers read before them would disappear and a simple list of titles could take their place, so greatly diminishing the field to be covered by any abstracting organisation.

There would remain the important group of publications comprised in the various technical newspapers. The leading ones often publish articles of a value at least equal to many of the papers read before the Institutions, their authors apparently preferring the wider publicity and immediate publication afforded by a standard weekly newspaper to the facilities offered by any Institution, however important. How should such an article be dealt with? The writer would suggest that exactly the same course should be followed as in the above proposals, i.e., each newspaper should publish a separate abstract of every important article appearing in it uniform with the abstracts of Institution papers. By hypothesis the Institution abstracts are self-supporting, and no sane person would object to a small addition to the price of the newspaper abstracts to allow for profit; probably the same selling price would admit of such profit, since a newspaper would produce more cheaply than Institutions can buy. Discretion would have to be exercised in regard to the choice of articles to be abstracted. One obviously necessary rule would be that only original articles should be included, otherwise there would be overlapping of abstracting.

Those who were studying a subject seriously would doubtless wish in many cases to have the original paper and article for reference in addition to the abstracts, and although they must, as has been assumed, continue to vary greatly in size and shape, a good deal of inconvenience would be saved if Institutions would arrange that every paper should start on the front of a fresh page of the Proceedings. This would involve the second desideratum, namely, that the paper with its discussion should end with a clear space on the last page. Newspaper articles could not conveniently be dealt with in this way, and the inconvenience of irrelevant matter being included in a cutting must be faced. A further inconvenience which such cuttings have, especially from such large-paged papers as ENGINEERING and *The Engineer*, might be mitigated if the respective journals would issue a spring-back file or paste-in album specially suited for cuttings from their pages.

If these proposals were carried out in this country, still only British publications would be dealt with and the vast number of foreign publications would have to be abstracted on the same lines as now. Probably it would be possible gradually to obtain the adherence of foreign nations to an international scheme on the same lines, but it would necessarily be a good many years before the arrangement became general. Much might be done by the British Engineering Standards Association to bring about this international agreement by the persuasive powers of their polyglot, cosmopolitan but always British secretary, and so far as electrical work is concerned the International Electro-Technical Commission would greatly facilitate agreement.

It is believed that the scheme outlined above would be of material benefit to engineers and scientific men; at all events it has the merit, rare in these days, of not proposing to dip into the depleted pockets of the taxpayer, already nearly maddened by his burdens.

I am, yours truly,

C. H. WORDINGHAM.

"THE DETERMINATION OF THE LOADS ON CRANE WHEELS."

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of July 9, Mr. Montagnon, referring to my criticism of his methods on the ground that his centres of rail loads do not lie on a line *perpendicular* to the track, says that this criticism is directly opposed to my previous criticism on the ground that they do not lie on one of the *diagonals* of the truck. Actually, Mr. Montagnon's centres lie on an oblique line falling between the perpendicular and the other diagonal, so that both my suggestions differ from his methods in the same direction, both showing a larger maximum wheel load. Moreover, the suggestion that the centres should lie perpendicularly opposite one another was made in connection with a crane with *springy* cross-girders, while the suggestion that they should be diagonally opposite was made in connection with a *rigid* truck on badly laid rails. The difference in the conditions justifies the difference in treatment.

The consistency of results obtained by his methods, on which Mr. Montagnon places so much stress, is dependent on ignoring the varying conditions, and making the same assumptions in all cases. Equal consistency of results will be obtained by the older method if one set of assumptions is always made in applying it, and those assumptions will almost inevitably be truer in the case of cranes that are not spring borne than the assumptions underlying Mr. Montagnon's methods.

I regret that Mr. Montagnon has not dealt with my arguments, but has devoted himself to a somewhat unsuccessful attempt to discover a flaw or inconsistency in my manner of statement, and I agree that further discussion of this kind would be useless.

Yours faithfully,

W. W. PADFIELD.

2, Cedar Villas, Bath, July 10, 1920.

"THE GERMAN LONG RANGE GUNS."

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to the most interesting and instructive article on Germany's long-range guns, in your issue of July 2, I would like to point out, with your permission, that in 1912 there was a discussion in Newcastle-on-Tyne which opened upon the effect of the "droop" of a large-calibre gun upon the path of a projectile, and whether the high-velocity projectile neutralised or aggravated the existing droop during its passage through the last 10 calibres of gun length.

The very inner tube construction now shown as being the long-range gun feature of German ordnance, was brought forward as a compromise—not to provide additional linear velocity, but that the projectile should leave the muzzle approximately along the same axis as when it commenced to move. The question of additional linear velocity with this smooth bore portion had no support, it was considered that the leakage past the copper band would tend rather to reduce the velocity—using the then standard propelling charge.

The length of smooth bore then suggested was equal to one complete turn of the rifling. I have not heard of, or seen any record that this feature was adopted, even to maintain projectile alignment by our own experts during the great war.

Possibly the reason the German engineer, working with the American forces would not discuss the details of their long-range gun, was much the same as that which allowed this feature to be neglected in our own ordnance design.

Yours faithfully,

THOS. HARLAND.

69, Northfield-road, New Moston, Manchester, July 9, 1920.

"CITROEN GEAR FOR ELECTRIC LOCOMOTIVES."

TO THE EDITOR OF ENGINEERING.

SIR,—On page 712 of No. 2,839, vol. cix, dated May 28 last, you published an article entitled "Citroen Gear for Electric Locomotives." With reference to this article we beg to say that the mechanical part of the locomotive No. 121 of the Bernese Alpine Railway Company, as well as the mechanical part of the 12 locomotives of the type 1-E-1 (2-10-2) was constructed by our works, i.e., the Swiss Locomotive and Machine Works at Winterthur, and that these works, and their technical manager, Mr. O. Kjelsberg, first proposed the insertion of elastic intermediate members in the shape of laminated springs, when the critical speeds have been experienced. The Swiss Locomotive Works then further improved the elastic arrangement of the tooth gears and obtained a patent for the same. We further beg to point out that all electric locomotives of the Swiss Federal Railways have accordingly been provided with spring tooth pinions by the Swiss Locomotive Works.

We shall be glad if you will kindly complete the above-mentioned article by inserting the above remarks in your esteemed paper.

Thanking you in advance, we are, dear Sir,

Yours faithfully,

SWISS LOCOMOTIVE AND MACHINE WORKS.

P. HARDINGS.

Swiss Locomotive and Machine Works, Winterthur (Switzerland), July 6, 1920.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Little change of any kind has taken place in the Scotch steel trade over the week and active conditions have ruled throughout the industry. Buyers are perhaps not just so numerous of late owing to the general idea that top prices have been reached, and in anticipation of an easing-off they have been withholding fresh business, but the prospect of advanced railway rates is still in front of us, and it is only problematical what these will amount to and what will be the effect on prices. Makers, on the other hand, are still not over anxious for further heavy commitments on account of the large amount of work already booked forward. As that gets worked off they will be more ready to consider favourable specifications, but for some months ahead they are fully booked up. During the past week there has been the usual pressing demand for deliveries of all classes of material, with shipbuilders well in the front line. In the steel sheet trade the extremely active conditions continue, and no effort is being spared to make improvements in deliveries to customers, all of whom keep pressing for supplies. For galvanised sheets there is a steady demand. Prices all round are very firm and the arrival of some steel sheets from the Continent has not had any weakening effect on the market.

Malleable Iron Trade.—The home demand for malleable iron continues strong, and the West of Scotland makers are all very busy. The output is large, but not large enough to meet the requirements of consumers who are, in many cases, rather inclined to listen to the sellers of the Belgian bars. So far, little of the latter has been offered although the probable price named is a good way easier than what the local producers quote. Over all the position is practically unchanged, and with the bulk of the present make being consumed at home the export trade is almost neglected.

Scotch Pig-Iron Trade.—In the Scotch pig-iron trade the prevailing feature is still the great scarcity of all grades, foundry iron being particularly so. Deliveries are on a large scale, but there is so much stuff booked that it must be a long time before makers can possibly clear off their arrears. In the case of hematite iron there exists a very heavy demand from steelmakers owing to the activity at their works and deliveries get quickly consumed. Prices keep very strong, with no signs of easing. Supplies of raw material show a slight improvement, but are still a long way behind what is desired. The bulk of the present production continues to be used up by the home trade and export business is but a shadow of its former self, in fact, it is really infinitesimal. With a shortened holiday at this time the smelters are to endeavour to increase the amount available for delivery when the various industries resume operations after the annual vacation.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The position of trade generally is far from satisfactory. The serious shortage of pig-iron is causing increasing difficulty in the operation of local foundries. This is largely due to heavy exports to Italy, France and Belgium, which have been encouraged by the Government with a view to setting the industries of those countries on their feet. The result has been the serious hampering of trade in this country, and representations have been made to the Government that home needs should be to some extent considered before iron is allowed to go abroad. Though promise of consideration has been received by founders, export is still continuing, and the home supply is very limited. The shortage of castings is having its effect on the engineering and building industries, which have not yet recovered from the effects of the moulders' strike. The latter industry is suffering severely from shortage of labour. During the strike many of the moulders drifted into other occupations, and some thousands of skilled men have been lost to the trade. Complaints are heard on all sides of a falling-off in the demand for high-speed steel. The open-hearth furnaces have an easier demand for ingots and billets. Consumers, however, are taking substantial deliveries, and rolling mills have plenty of work on hand. The tool trade is a varying quantity. There is a good demand for files, but business in engineers' and small tools is quiet. An increased call is reported for railway axles, tyres and springs; this is chiefly from British railways. The paucity of Indian and foreign orders, however, is causing some uneasiness among makers. Plant has been substantially added to of recent years, and to maintain anything like full employment a much heavier business will have to be done than is at present coming forward.

A Responsible Appointment.—Mr. G. B. Brook, lecturer in non-ferrous metallurgy to the University of Sheffield, has accepted the responsible position of chief chemist to the British Aluminium Company. Mr. Brook's connection with the light industries of Sheffield extends over thirty years. He was trained under Mr. A. H. Allen, public analyst for Sheffield and the West Riding, and was the first lecturer in non-ferrous metallurgy at the Sheffield University. During the war he was closely identified with the work of the Sheffield Munitions Committee, and subsequently in the establishment of the Wounded Officers' Training Department in non-ferrous metallurgy. His departure will be a distinct loss to the City of Sheffield.

South Yorkshire Coal Trade.—The general position in the coal trade has undergone little change during the past week, the stoppage of further restrictions having had a marked effect upon the home market. In spite of the fact that a good deal of "loco." coal has been relieved for household purposes, gas and railway companies are now putting down stocks against the coming winter requirements. Manufacturers are making heavy demands for industrial coal, and the pits are very fully occupied. Small fuel is easier, but prices remain unchanged. Blast furnace coke continues steady at 65*s.* 9*d.* per ton at the ovens. In household fuel merchants are anxious to increase their depot stocks. The public is not yet placing stocking orders at all freely. Apparently householders are waiting to see if prices will be reduced on the demand of the Miners' Federation, which merchants regard as a very unlikely eventuality. Quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Cleveland pig-iron continues exceedingly scarce. With the commencement of the Fair Holidays in Scotland deliveries to customers beyond the Tweed are suspended, but home demand from all other quarters is more than can be dealt with. Makers self-imposed embargo on sales abroad is rigidly adhered to, and there are no export quotations, but if hope of increased output by setting in motion idle plant is realised, we may shortly see resumption of trade with buyers abroad, particularly Scandinavia, where American supplies have been disappointing. To home customers, No. 1 is 230*s.* and No. 3, as well as the inferior grades of Cleveland pig-iron, is 217*s.* 6*d.*

Hematite Iron.—Producers of hematite iron are well placed. Few of them will discuss business for delivery earlier than the last quarter, and some firms are fully booked for the year. At the same time, in addition to the very limited home business passing, occasional small odd parcels can still be purchased for despatch to the allies. For home use, Nos. 1, 2 and 3 are 260*s.* and No. 1 is 262*s.* 6*d.*; and for shipment to France, Belgium and Italy, mixed Nos. are 265*s.* and No. 1 is 267*s.* 6*d.*

Blast-furnacemen's Wages.—A further advance is announced in North of England blast-furnacemen's wages, due to the average net selling price of No. 3 Cleveland pig-iron for the second quarter of the year having been certified at 203*s.* 8·96*d.* per ton, which under sliding scale arrangements advances rate of pay by 25·25 per cent., raising wages from 124·25 per cent. above the standard to 149·50 per cent. above the standard.

Coke.—Demand for coke keeps strong. The home market, for which there is an ample supply, is active, but foreign business is very difficult to arrange. For home purposes foundry description is 70*s.* 3*d.*; average blast-furnace kind is 62*s.* 9*d.* at the ovens, and low phosphorus sort is 65*s.* 3*d.* at the ovens. For export, foundry coke is 200*s.*, and gas-house product ranges from 215*s.* to 220*s.*

Foreign Ore.—There is a decidedly weaker feeling in foreign ore. Sellers are becoming quite eager to enter into contracts, after the very prolonged lull, but consumers are still holding off, believing that market movement is likely to continue in their favour. The recognised basis of quotations remains at 49*s.* for rubio of 50 per cent. quality, on the 17*s.* parity freight, Bilbao-Middlesbrough, but that is now quite a seller's price. The last reported chartering from Bilbao was at 23*s.* 9*d.*, and as only 22*s.* 6*d.* is now being offered, the outside ex-ship Tees value of best rubio must be 55*s.* 9*d.*

Manufactured Iron and Steel.—Quietness characterises the various branches of the finished iron and steel industries so far as new business is concerned, but manufacturers are very busy on existing contracts, and values of all classes of material are upheld, notwithstanding American and Belgian competition. Common iron bars are 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; steel ship, bridge and tank plates, 23*l.* 10*s.*; boiler plates, 30*l.*; steel angles, 23*l.*; steel joists, 23*l.* soft steel billets, 25*l.* 10*s.*; hard steel billets, 26*l.* 10*s.*; heavy sections of steel rails, 23*l.*; fish plates, 28*l.*; black sheets, 44*l.* 10*s.*; and corrugated galvanised sheets, 56*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Limited Exports and Unemployment.—The limitation of coal exports by the Government has resulted in serious unemployment at the Bristol Channel ports, and representations have been made to the authorities by representatives of various trades unions with a view to getting the restrictions either removed or materially modified. Not only are those directly engaged in the shipping of coal affected but also dry-dock workers and seamen, besides import dischargers. It is obvious that a reduction in coal exports involves a smaller quantity of tonnage to take the cargoes away, and consequently fewer vessels are coming to the district. It is stated that over 2,000 sailors are seeking employment besides some thousands of transport and dry-dock workers. Coal trimmers in many instances are only working one shift a week, and 80 Cardiff tippers are working under notice. Unless there is a substantial increase in the quantity of coal allowed for export there is little doubt that the district is in for a bad time and the remedy lies mainly in the hands of the miners in the way of increased production; the present output is not nearly sufficient to meet the home and foreign requirements, and as home industries are entitled to preference exports must necessarily be limited.

The Coal Markets.—Little new business was again possible on the coal markets as practically the whole of colliery export allocations were absorbed by contract commitments. The exportable cargo quantity has been slightly increased, but is still less than the district is entitled to under the limitation scheme. The restrictions of the Coal and Coke Supplies Committee necessary for the purpose of seeing that the limitation scheme is carried out making it difficult for collieries and exporters to carry on and also causing delay to shipping. Not a pound of coal can be sent away without filling up numerous forms, so that the conditions governing business just now are very irksome. Pre-entries for foreign cargoes and bunkers will not be considered without permits for the required quantities, and as many collieries are running short of these permits business is more difficult than ever. Again the local inland demand is almost negligible, and collieries as a result are in danger of stoppages as they have in the majority of cases already shipped their export allocations and, therefore, if they cannot find inland purchasers must stop their pits until a fresh supply of coupons are issued. Though there has been a substantial increase in the make of patent fuel free supplies are very scarce and worth 140*s.*

The Iron and Steel Trades.—A settlement has been reached in the wages claims of tin-plate workers. Twenty-five per cent. of the special war bonus is to be consolidated into the base rate, and 25 per cent. of the special bonus and the existing war bonus is to be paid on the new base rate. This arrangement is to date from July 4, and will be temporary until such time as a sliding scale is settled. Meantime the demand for tin-plates is quiet with prices easier at 63*s.* to 65*s.*, but the wages advance, it is believed, is bound to increase costs to an appreciable extent.

LINCOLN TRACTOR TRIALS.—We are informed by the Society of Motor Manufacturers and Traders, Limited, 83, Pall Mall, S.W. 1, that the ploughs to be used in the respective classes have been selected as follows: (1) Hornsby; (2) Ransomes; (3) Martin; (4) Martin. In this connection, the society add that the Trials Committee first decided that all the machines in any one class should pull the same type of model of plough. Subsequently, they limited the ploughs from which a selection should be made to those of British manufacture, and, finally, they decided to make the selection by ballot. The result of the ballot is the above. The mere fact that any particular plough has not been selected for the work does not reflect in any way on that plough, since, as will be seen, the choice was on a basis of chance only.

NOTICE OF MEETING.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Summer Meeting at Lincoln, July 20 to 23. Tuesday, July 20, in the Lecture Theatre of the Municipal Technical School: 10 a.m. Welcome by the Mayor of Lincoln, followed by a lecture on Roman Lincoln by Lieutenant-Colonel E. M. Sympson. Papers will be subsequently read and discussed. In the afternoon there will be visits to the works of Messrs. Clayton and Shuttleworth, Messrs. Robey and Co., Messrs. Clarke's Crank and Forge Company. 7 p.m. The Institution Dinner. Wednesday, July 21: 10 a.m. Papers to be read and discussed. In the afternoon, visits are arranged for the works of Messrs. William Foster and Co., and Messrs. Ruston and Hornsby. 8 p.m. Reception in the Castle Grounds. Thursday, July 22: Alternative visits have been arranged to Scunthorpe to inspect the Frodingham Ironstone Mines, Messrs. Lysaght's Ironstone Mines, and Messrs. Lysaght's Normanby Park Steel Works; or to Newark, to the works of Messrs. A. Ransome and Co., Messrs. Worthington-Simpson and Messrs. Ransome and Marles Bearing Company. Friday, July 23: Excursions have been arranged to Gainsborough, to the works of Messrs. Marshall, Sons and Co., and Messrs. Rose Brothers, or to the Dukeries. The following papers will be taken as far as time permits at the Tuesday and Wednesday morning meetings: "Recent Excavator Practice," by Mr. F. H. Livens and Mr. W. Barnes; "Road Transport, by Steam Vehicles," by Mr. P. W. Robson; "Some Lincolnshire Oil Engines," by Mr. F. H. Livens; "The Human Factor in Industry," by Mr. A. Ramsay; "The Uniflow Steam Engine," by Mr. F. B. Perry; "The New Power Station for Messrs. Marshall, Sons and Co., Gainsborough," by Mr. F. J. Cribb.

BRITISH PRODUCTION OF IRON AND STEEL.—The British production of pig-iron in June amounted to 726,000 tons, or 13,000 tons less than in May; but the June production shows a better daily average. The production of steel ingots and castings was 845,000 tons, or 1,000 tons less than the total for May. The pig-iron production for the first half-year was 4,145,000 tons, as against 3,954,000 tons for the first half-year of 1919; and the production of steel ingots and castings 4,877,000 tons, as against 4,254,000 tons for the first half-year of 1919.

INSTITUTE OF TRANSPORT.—This Institute, in sending the names of the new corporate members elected, announces that it will give the following premiums. An Institute gold medal, to be awarded triennially for the paper read, or contribution to the proceedings made, during the preceding three years, judged first in order of merit. Two gold medals awarded annually by the Railway Companies' Association for the best paper or contribution on railway (*a*) operating and (*b*) engineering subjects. Two gold medals awarded annually, one by the Commercial Motor Users' Association, and one by the London Underground Railways and London General Omnibus Group for the best paper or contribution on road transport subjects, goods and passenger, respectively. A gold medal to be awarded annually for the best paper or contribution on subjects relating to tramways and light railways. A gold medal to be awarded annually for the best paper or contribution on subjects relating to inland waterways, docks or coastwise shipping. The Institute has also issued a list of the subjects on which it invites papers or contributions.

THE ELECTRICALLY-WELDED SHIP "FULLAGAR."—The welded motor-ship Fullagar has just carried out very successful sea trials. We described her on page 25 *ante*, and her engine on page 144 of our last volume. For running from full speed ahead to full speed astern, at trials made on June 29, in the Mersey, only about 10 seconds were required, the engine easily starting action with full ahead way on the ship. At 11.40 p.m. on the same day, the ship set off on her maiden trip to the Clyde. After getting clear of land, extremely rough weather was encountered, and it was found necessary to put into Ramsey until the storm abated. The engine ran steadily throughout and the hull withstood the severe shocks and stresses of the waves. The ship left Ramsey at 4.20 a.m. on July 1 and reached Greenock at about 6 p.m.; the engine continued to run steadily at a speed of 106 r.p.m., the ship doing about 9·75 knots against wind and tide. On July 2, trials were run on the mile, also manœuvring tests. The ship then left the Clyde at 11.30 p.m. on July 2, and arrived in the Mersey at 8 p.m. on July 3; the engine ran satisfactorily, &c., without any sign of trouble from start to finish, at an average of 107 r.p.m., the speed averaging about 10 knots. During this run the fuel consumption worked out at 2·1 tons per 24 hours. Some readings are as follow:—

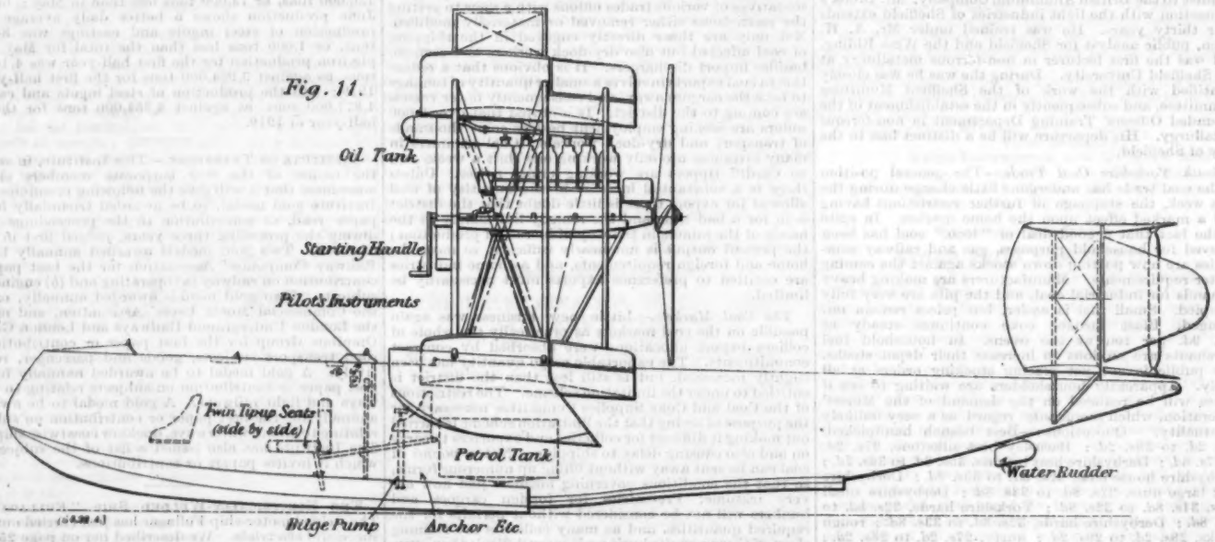
	Lb. per Sq. In.
Scavenging air pressure	1½
Circulating water pressure	6·5
Lubricating oil pressure	12
Blast air pressure	1,000
	Deg. F.
Scavenging temperature	50
Circulating discharge temperature...	100
Engine-room temperature	62

A large number of engineers and shipbuilders from all parts of the country who witnessed the trials on board expressed satisfaction at the running of the engine and the promptness with which all orders from the bridge were executed, the engine never failing to respond to any order required.

AEROPLANES AT THE INTERNATIONAL AERO EXHIBITION.

(*For Description, see Page 74.*)

FIG. 10.



FIGS. 10 AND 11. SUPERMARINE CHANNEL-TYPE BOAT SEAPLANE.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Before concluding the present session of the Institution of Petroleum Technologists, Sir Frederick Black, K.C.B., B.A., had announced that a series of seven lectures, open to all, would be delivered in the Crystal Palace in order to inform the general public on matters scientific and technical relating to the production, refining, transport and uses of petroleum oil—matters to promote the study of which the Institution was founded in 1914. The first lecture was given on Wednesday, June 30, by Sir Frederick himself, the fourth President of the Institution in succession to the late Sir Boverton Redwood, Sir John Cadman and Sir Charles Greenway. At some future date, which might be nearer than was generally supposed, Sir Frederick said, Europe, including the British Islands, might be large producers of petroleum from natural wells, shale, coal or similar substances; the educational work of the Institution was therefore of great importance.

TRADE WITH GREECE.—The report on the commercial and industrial situation of Greece, for 1919, by Mr. E. C. D. Rawlins, Commercial Secretary to H.B.M. Legation, Athens, states that the war gave the Greeks an opportunity for making the closer acquaintance of the British in general and of British goods, and the prolonged presence of the British troops in her territory and of British ships in her ports and around her coasts, created a certain amount of unconscious propaganda, with the result that the Greek traders became exceptionally well-disposed towards Great Britain, and were prepared, on equal terms, to give her the preference in trade. The Exhibition of the Federation of British Industries held in the Zappeion at Athens from October 19 until November 23, 1919, gave British manufacturers the opportunity of bringing their products to the notice of the Greek buyers. Prior to the war most of the Greek requirements of iron and metals in general were supplied by Germany, in virtue of the special tariff agreements in force for these articles. Considerable quantities were also supplied by Belgium. If British manufacturers can, in the future, compete with the German and Belgian prices, which they were unable to do in the past, an attractive opening exists for these lines.

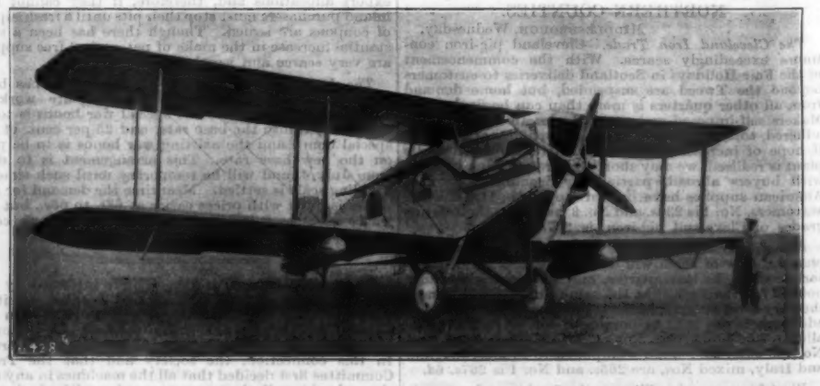


FIG. 12. WESTLAND LIMOUSINE COMMERCIAL AEROPLANE.

THE WORKS OF MESSRS. ROBEY AND CO., LIMITED, AT LINCOLN; THE STEAM WAGON DEPARTMENT.

(*For Description, see Page 65.*)

FIG. 2. THE STEAM WAGON ERECTING SHOP.

FIG. 3. THE STEAM WAGON MACHINE SHOP.

(*To face page 66.*)

THE WORKS OF MESSRS. ROBEY AND CO., LIMITED, AT LINCOLN; THE ENGINE ERECTING SHOPS.

(*For Description, see Page* 65.)

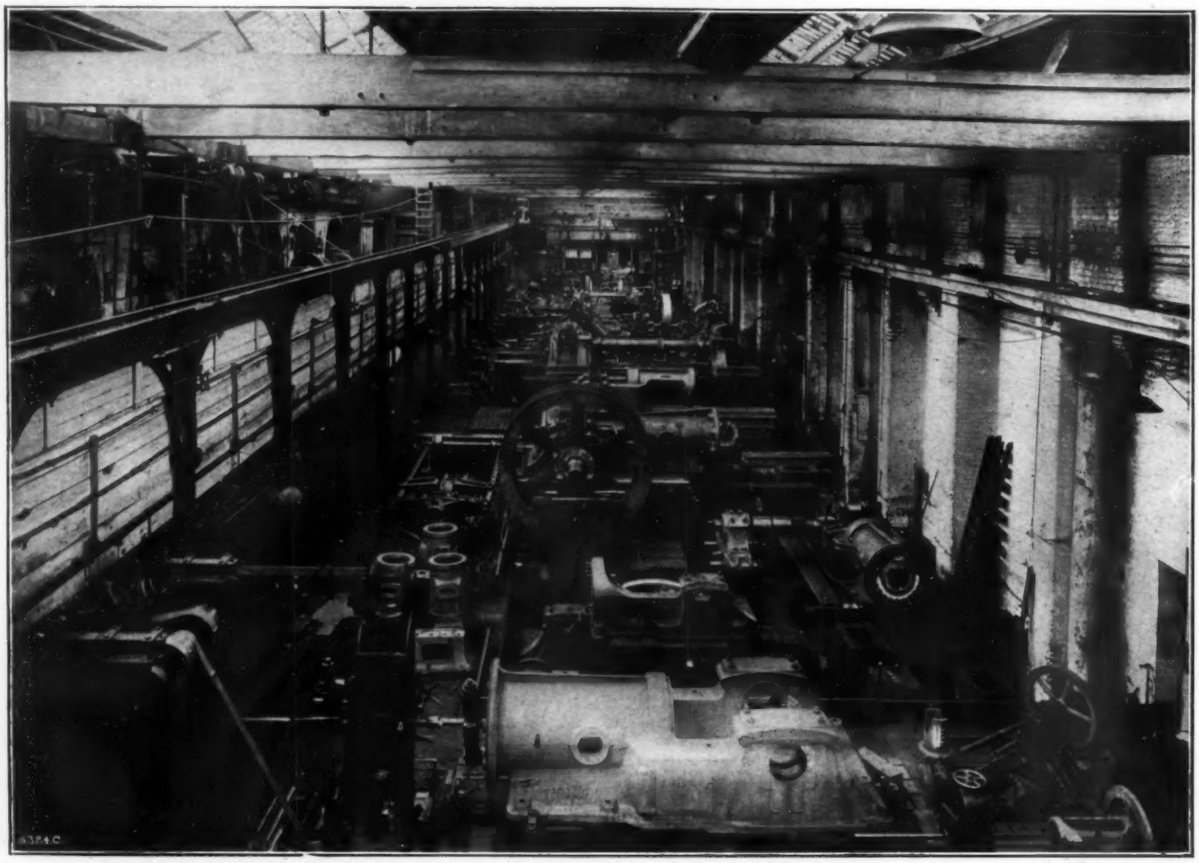


FIG. 4. UNIFLOW ENGINE ERECTING SHOP, FROM GALLERY.

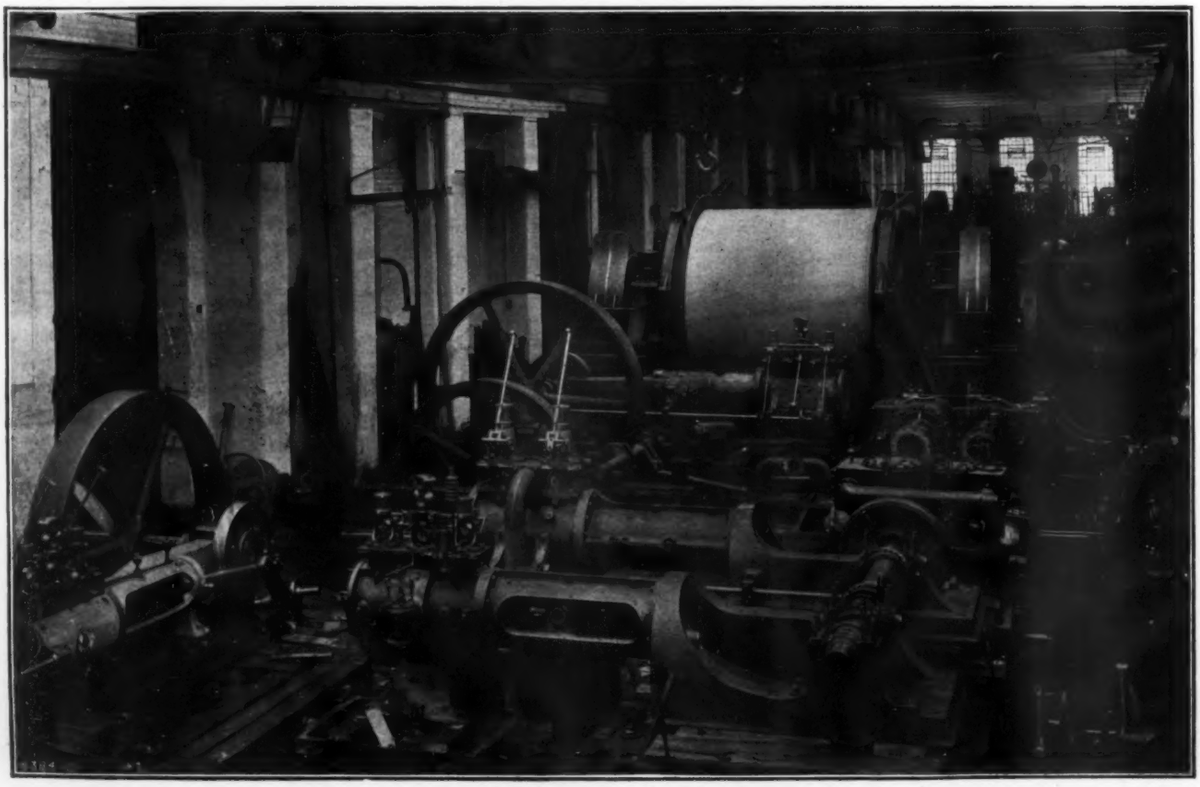


FIG. 5. WINDING ENGINE ERECTING SHOP.

THE WORKS OF MESSRS. ROBEY AND CO., LIMITED, AT LINCOLN; FIXED ENGINE ERECTING SHOP AND TEST BEDS.

(*For Description, see Page* 65.)

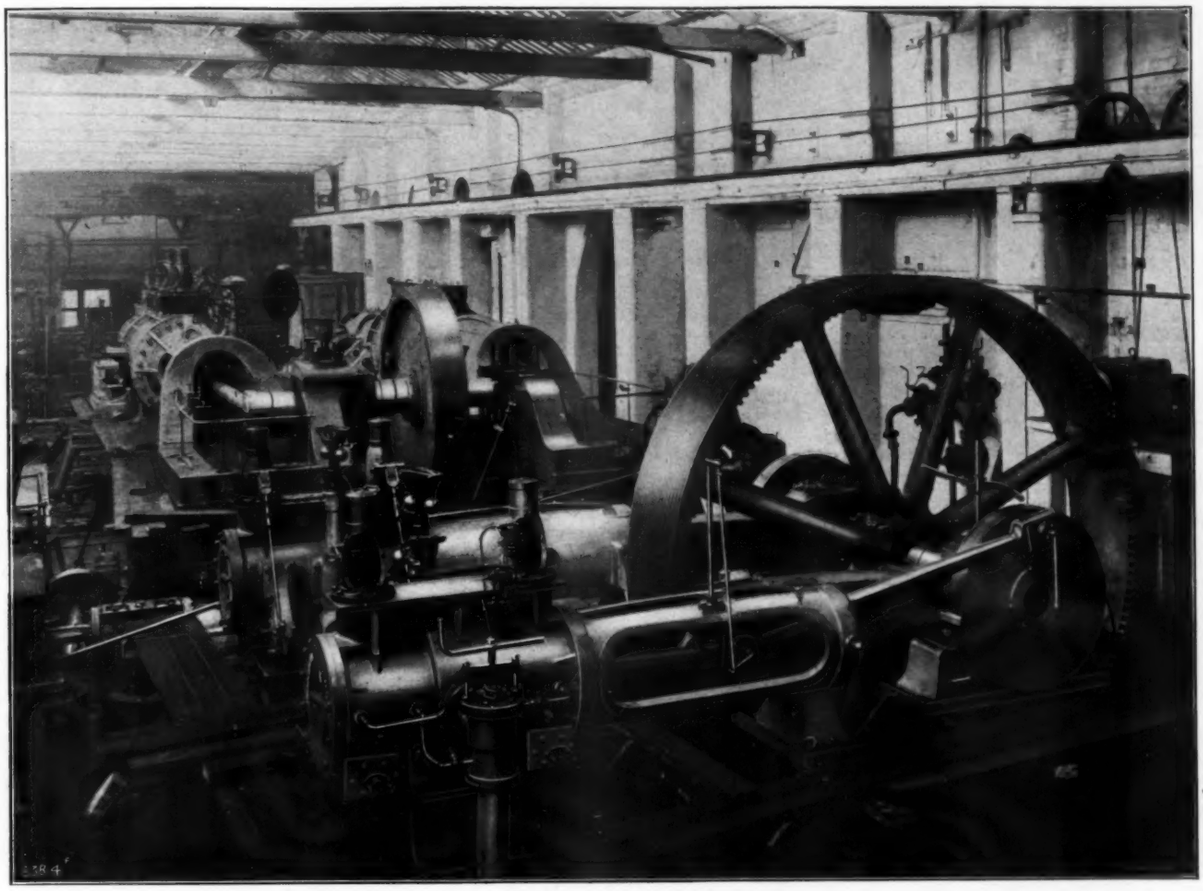


FIG. 6. FIXED ENGINE ERECTING SHOP.

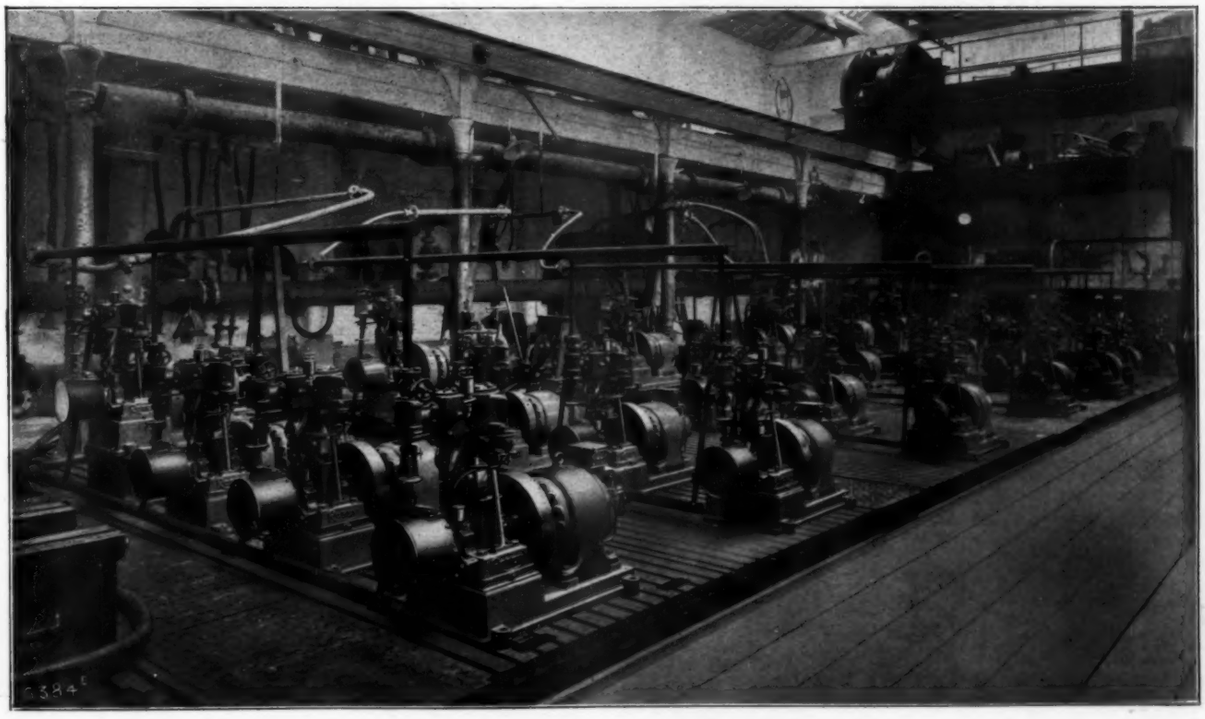


FIG. 7. TESTING BEDS FOR HIGH SPEED ENGINES.

FIVE-TON STEAM WAGON.

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

(*For Description, see Page* 66.)

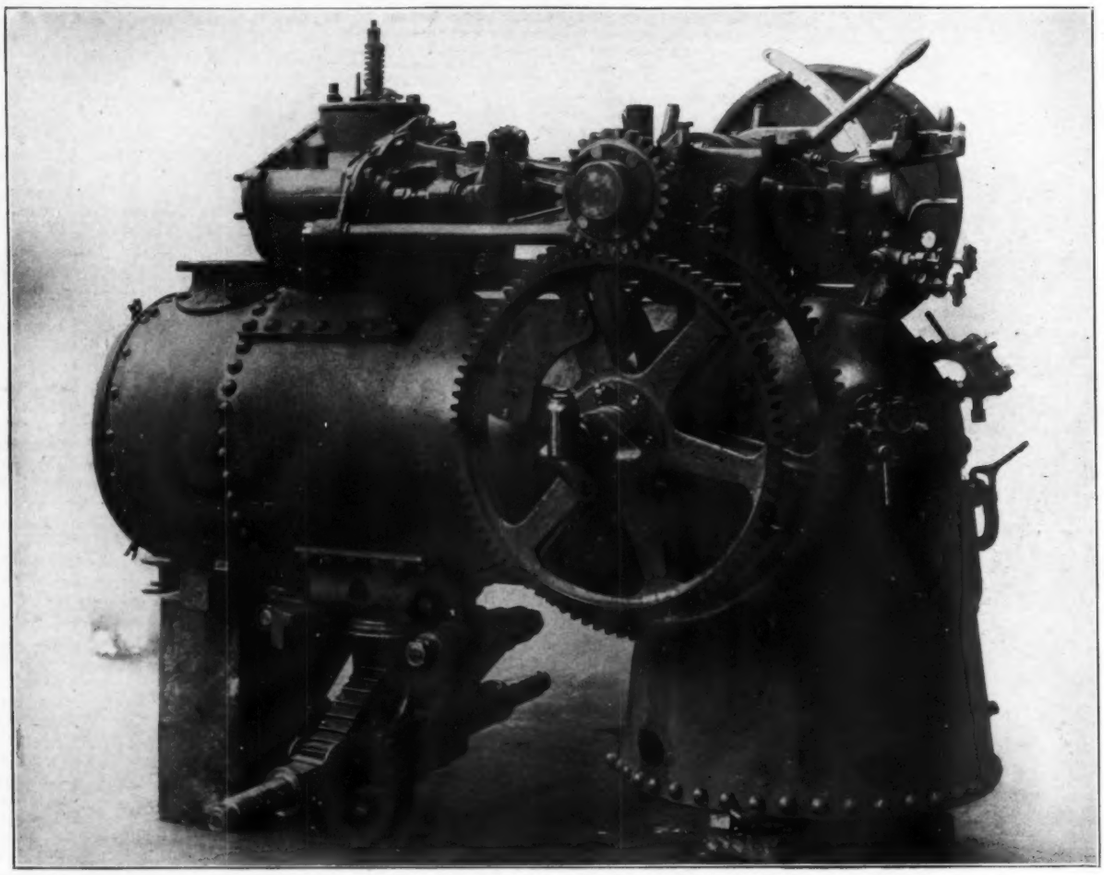


FIG. 8. BOILER AND ENGINE ASSEMBLED.

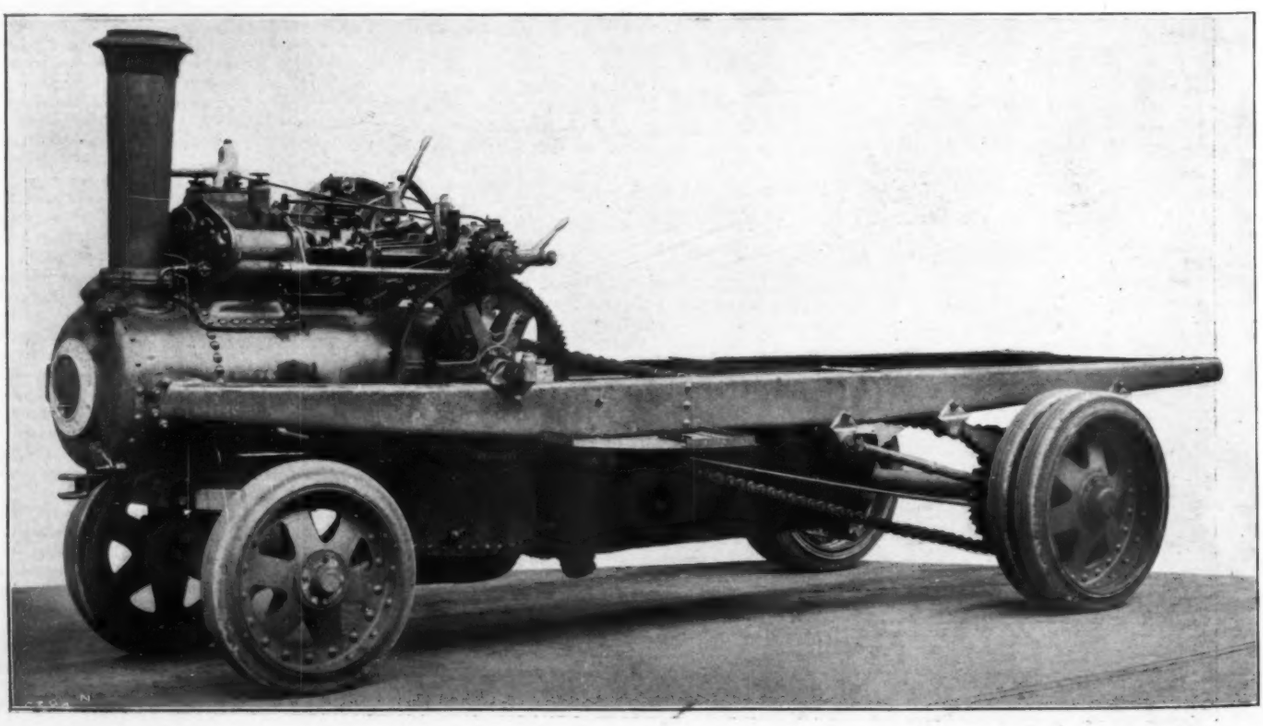


FIG. 9. ENGINE AND CHASSIS OF STANDARD WAGON.

(*To face page* 67.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3 3 0
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Thin paper copies	£2 18 6
Thick ,, ,,	£3 3 0
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Thin paper copies	£3 3 0
Thick ,, ,,	£3 7 6

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS: "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3643 and 8598 GERRARD.

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With Four One-Page Plates of the WORKS OF MESSRS. ROBEY AND CO., LIMITED, AT LINCOLN.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d. post free.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 81.

ENGINEERING.

FRIDAY, JULY 16, 1920.

GERMANY'S POST-WAR INDUSTRIAL PROBLEMS.

ONE of the conclusions arrived at in a report issued by the Department of Overseas Trade, on Industrial and Commercial Conditions in Germany at the close of 1919, is to the effect that, "as Germany cannot buy, so also she cannot produce," a conclusion with which we can hardly agree after reading the report in question. We should have been inclined to word the conclusion as follows: "If Germany will not produce, so also she will not be able to buy." The report opens with a chapter on Finance and Taxation, with which we do not propose to deal at any length, since the matters which it covers are outside our province. We shall only remark that this chapter states as an undoubted truth that the Allies' demands can, for the most part, only be satisfied through German labour and production; it adds (an equal truth) that the latter, that is to say both labour and production, are, amongst other things, seriously hampered by the state of the German exchanges. Hence, the report further says, a vicious circle is created from which Germany cannot escape except through outside assistance. The vicious circle is explained as being this:—Germany, owing to the severe depreciation of her exchange, cannot purchase food and raw materials, and until she obtains food and raw materials she cannot manufacture for export and thus improve her exchange. We repeat that we do not agree entirely with this finding, and we are strengthened in our opinion by the subsequent chapters of the report, especially by that dealing with Coal and Railways.

In regard to coal, we find the German output of this commodity, including brown coal, to have been in 1912, the last year for which we have data, 259,434,500 tons, according to an American authority quoted by *Stahl und Eisen*, whilst for the same year the British output was given as 257,136,000 tons. Since that year, Germany has lost several provinces, but this loss affects to a very much greater extent her iron ore producing capacity than it does her coal resources. It may be perhaps too much to say that these latter remain to her practically unimpaired, and we use the word unimpaired purely from the point of view of number of coalfields; nevertheless, she is now, as she was before the war, one of the principal coal-producing countries of the world. But according to the report from which we quote—and this is where our contention comes in—she cannot get her miners to work; hence Germany does not produce and is unable to buy. There have been "strikes from the time of the armistice till the summer of 1919," "endless interruptions," and so forth. Thus, in 1913, the average monthly production in the Ruhr area is stated to have been 9,545,000 tons. In the autumn of 1918 it was 8,669,000 tons; and in 1919, for September, October and November, an average of 6,563,000 tons per month. Therefore, latterly the average monthly production of the Ruhr area has been 68 per cent. of the average for 1913 and 75 per cent. of the amount for 1918. This falling-off may be due to other causes beside labour, but if German labour had given its best, production in the particular district of the Ruhr would have shown better results. This should be a national problem for Germany herself to solve. We may here point out that the monthly figure of 9,545,000 tons for the 1913 output of the Ruhr area gives an annual output of 114,540,000 tons, of black coal, a figure which, as will be seen, is nearly one half of the output in 1912 of both black and brown coal for the whole of Germany, above referred to; and the Ruhr area remains German.

That the depreciation of the mark is not alone responsible for the alleged unsatisfactory state of Germany principally as regards food is proved by another passage in the report with which we are dealing, where it says that "in agriculture, the lack of coal for ploughing, threshing, dairy and forge work, makes itself particularly felt," and by a further one according to which "another factor which had a very adverse effect on the nation's food supply was the shortage of bunker coal for trawlers, this condemning the trawlers to enforced idleness at frequent intervals." Agriculture and fishing, on which are based if not the whole, at all events by far the major part, of a nation's food supply, are purely national industries, and if the nation involved, Germany in the present instance, cannot settle matters by seeing to it that there is no lack of her own coal, we fail to see who can. The depreciation of Germany's exchanges, severe or otherwise, does not come into play here at all.

The general distress, to quote again from the report, is most strikingly reflected in the mining areas themselves, where the iron and steel industry is subject to endless interruptions. Of the 29 blast furnaces in the Siegerland, which smelt the local ores and are of vital importance to German steel production, only 18 are working, some at low pressure. The steel works of the same area have been nearly at a standstill for months past, largely through lack of coal. Further, and this deserves more than passing notice, the cement, the lime, the brick-making and the porcelain industries, all "obtain their raw materials in Germany, and three of them are of exceptional national importance in view of the housing question, whilst the porcelain industry is needed to help in the creation of foreign credits," and all these industries are restricted owing to the lack of German coal supplies. Further still, there are about 80,000 railway trucks requiring repair; only half this number can be accommodated in the shops, the remainder standing on sidings and on unused tracks, where they deteriorate and are stripped by the population. The number of locomotives needing repair, but on which work has not commenced owing to the idleness and indifference of the workmen, has risen from 1,700 during the second half of 1919 to nearly 2,000 by the middle of January last. In all these matters, outside aid and the improvement of the exchange have no bearing at all on the situation. The Krupp Company are said to be manufacturing at the present moment cash registers, locomotives and trucks, among other articles of commerce. They cannot export any of these and, if all accounts are true, there is probably no market yet for the former article even in Germany. Would not the Krupp Company be able to undertake the repair of the locomotives and trucks referred to? In their yards, this material would be, at any rate, protected from depreciation and from the depredations of the population. But this, again, is a point for Germany herself to decide.

Curiously enough, on exactly the same day, on which the above report came to hand, we received from Paris the latest issue, for April last, of the *Revue de Métallurgie*; the first article in this issue is an account of the systematic destruction by the Germans of the Denain and Anzin Works, in the North of France. This is the commencement of a series which the Paris review is going to publish, in order that ". . . foreign nations, whether allied or neutral, may know exactly the extent of the sufferings of the French industry." No German

works have been destroyed at all; none of Germany's coal shafts have been damaged internally, as was the case with French mines damaged almost beyond repair by the explosion of bombs and torpedoes dropped down them. If that had been the case, considering the laments which Germany has not ceased to make since the armistice notwithstanding the fact that her installations and plants are practically intact, the mind of even a superman—if there exists such a being—is totally unable to realise what would be her present situation and to what impossible extent she would be now bemoaning the depreciation of the mark.

In shipping, we find again that shortage of fuel and material intervened as well as labour troubles. Further, in order to keep their *personnel* employed, the Hamburg America Line and the German Lloyd have purchased several large hotels, and are also doing business as import and export merchants. The former company has maintained its interest in aerial transport, and it is stated as probable that it will participate in commercial aviation on the Continent when the possibility for this arises. The activities of other German companies in regard to aviation are also entered into.

The report is based upon statements of the Reichsbank, reviews of the German financial situation by Herr Erzberger, remarks of the German Coal Controller, and other remarks by the chairmen of iron and steel companies. With reference to this we may say that although no allied officer in command has ever let us into the secret of the manner in which, during the war, he dealt with information that reached him from a purely German source, it is quite reasonable to surmise that he divided it probably by a factor and that he then acted upon the quotient. We have been told that such a method of treating enemy information was followed in former wars. It would seem to us that a similar method could very well be applied at the present time in regard to all information of a financial, industrial or commercial nature which reaches the outside world from Germany.

At the meeting on Wednesday, June 23, of the Labour Conference at Scarborough, one of the delegates, Mr. Tom Shaw, M.P. (textile workers), is reported to have said that he had recently the opportunity of visiting three of the capitals of Central Europe. He added that those who visited Berlin must recognise the difference in the people, must see the signs of underfeeding, and must feel that the misery that was being inflicted upon men, women and children was damnable. But what Mr. Shaw probably fails to recognise is that the misery he alludes to is inflicted on the country by Germany herself. Agriculture, fishing and other trades which are independent of all outside influence, cannot continue, as noted above, owing to the lack of German coal and to the apathy of German labour. It is perfectly evident that Germany has suffered by the war; she started it, she lost, and it is perfectly evident also that she should pay the bill. She most certainly would have required the Allies to do so, and to the very last penny, had they lost. Her difficulties are of her own making, and continue to be so on the showing of the authorities referred to in the report. When her population sets to work, if there still be signs of underfeeding, then will it be time enough for British labour to show its sympathy.

Leaving out of consideration altogether in this article our own national problems, we may say that by far too much attention is paid to Germany's situation and to her complaints, and much too little heed given to the difficulties which Belgium and France have to contend with. The reason may be that both these allied nations are working bravely at the problems which face them, problems which are none of their own creation. They are faced, indeed, with the re-making of practically their whole mining industry, their iron, steel and other industries and commerce, and are contending against tremendous odds. Their people can show signs of underfeeding and worse, and the misery that has been inflicted upon Belgian and French men, women and children is indescribable. To give only one illustration, out of very many, some of their works can only run one-fifth of their steel furnaces by reason of lack of coal, and this at a time when the whole of their resources, and more, is needed to make good what has been destroyed, quite apart from manufacture for exchange purposes, to secure a living for their population.

We have heard it predicted here that both France and Belgium will recover from the effects of the war, speaking from the industrial and commercial standpoints, earlier than the other belligerent nations. That may be so, and it may not. If it be, it will be greatly to their honour, but that thought should not lead us to forget their past and present sufferings and difficulties whilst contemplating Germany's industrial and commercial conditions.

WORKMEN'S COMPENSATION.

THE report of the committee appointed last year by the Home Office to inquire into the working of the present system of Workmen's Compensation has now been published and merits the careful consideration of employers if for no other reason than that its proposals, if given effect to, will involve heavy charges upon industry.

The governing principle of the Workmen's Compensation Acts of 1897 and 1906 was that the payments to be made by employers under the Acts represented compensation for loss of earnings due to accident, and the amount of compensation was fixed primarily with reference to the amount of the injured workman's earnings. That principle has been abandoned to some extent by the committee in their anxiety to provide that the children of a workman who has met his death by accident in the course of his work should have a reasonable chance of becoming healthy and intelligent members of the community. The committee say, "Within proper limits all interests should be subordinated to the attainment of this object." Accordingly they recommend that in cases of fatal accident the amount of the compensation should be determined not with reference to the amount of the workman's earnings, but rather with reference to the number and category of those who were totally dependent on his earnings. They propose that the widow should get a lump sum of 250*l.* as compensation, and that weekly allowances varying from 6*s.* to 10*s.* a week should be paid for each child until it attains the age of 15 years. As this would involve employers in a liability of an uncertain amount, the committee propose that in the case of each death where a family is left, a uniform payment of 500*l.* should be paid into a central fund from which all payments of compensation to the children of deceased workmen will be made. The employer's liability would thus be 250*l.* where there was a widow but no children, 500*l.* where there were children but no widow, and 750*l.* in the case of a widow and children. Where there are other total dependents the maximum compensation for them is to be 50*l.*, so that the total maximum liability for compensation in respect of a workman's death will be 800*l.* instead of 300*l.* as at present.

In cases where the injury results not in death but in total incapacity, the committee adhere to the principle that the amount of the compensation should depend on the amount of the worker's earnings; but by a majority they recommend that in such cases the weekly compensation should be raised from 50 per cent. to 66⅔ per cent. of the worker's average weekly earnings, but with a maximum of 60*s.* instead of 35*s.* as at present. As regards the increase from 50 per cent. to 66⅔ per cent., the committee say that it has been pressed upon them that the employer and the workman should share the loss in equal proportions, but they say that the workman appears to get the worst part of the bargain inasmuch as he has to bear the pain and suffering and often has to incur expense in providing medicine and extra nourishment with a view to his recovery. Here they overlook or disregard the principle that compensation should be paid in respect of loss of earnings and not in respect of pain and suffering, and the fact that in many cases employers have to pay compensation for accidents which are due to the fault or negligence of the workers. Three members of the committee, Sir Walter Kinnear, Sir Alfred Watson and Mr. W. R. L. Trickett of the Treasury, dissent from this recommendation. They consider that the compensation should be on a basis of 50 per cent. on the worker's earnings, with a maximum of 50*s.*

In cases of partial incapacity, the committee recommend that the weekly payments should be two-thirds of the difference between the worker's average weekly earnings before the accident and the average amount which he earns or is able to earn in some suitable employment after the accident. There is a provision for a review of the amount in the event of a subsequent increase or decrease of at least 20 per cent. in the district rate of wages in the man's previous employment.

It is proposed that the waiting period be reduced to three days—*i.e.*, that compensation is to be payable as from the fourth day of the incapacity.

One of the main questions which the committee had to consider was whether employers should be compelled to insure. The committee—Mr. Trickett dissenting—recommend that insurance should be compulsory except in the case of the Crown, local or other public authorities and employers with an annual wage roll averaging more than 20,000*l.*

The committee are not in favour of the establishment of a State system of accident insurance, but they propose certain modifications in the existing system with a view to restriction of the expenses and profits of insurance companies in workmen's compensation business. At least 70 per cent. of the premium income is to be expended in benefits, the remaining 30 per cent. being available for management expenses and profits, including agents' commission, which is not to exceed 5 per cent. It is recommended that mutual insurance associations be placed under the same obligations as insurance companies regarding the furnishing of reports and information and the setting aside of funds to meet outstanding liabilities.

The present Acts do not apply to non-manual workers whose remuneration exceeds 250*l.* a year. The committee recommend that in future the Act should apply to non-manual workers whose remuneration does not exceed 350*l.* a year.

Another important recommendation is that a Government officer or Commissioner should be appointed to exercise various administrative functions and to take over the duties in connection with workmen's compensation at present exercised by the Home Office; and the committee suggest that the Commissioner should proceed with inquiries into many of the matters which they have not had time to deal with fully. The opinion is expressed in the report that the extra cost to the department in which the proposed Commissioner and his staff would be employed should not exceed 30,000*l.* a year (excepting the expenses of the administration of the fund for children's allowances) and it is considered that this should be defrayed by the Treasury. It is significant that the representative of the Treasury (Mr. Trickett) and Sir Alfred Watson dissent from this recommendation and indicate that they consider the estimate unreliable.

The report, which extends to 82 pages, contains many other important recommendations too numerous to be referred to here, but it will be apparent from what has been said that the matter calls for the immediate attention of employers.

THE LATE LORD FISHER.

ENGINEERS are better able than most to appreciate the debt of the nation to that great public servant Admiral-of-the-Fleet Lord Fisher, whose death occurred last Saturday. He was in his 80th year, having been born on January 25, 1841, at Rambodde, in Ceylon. The accident of his birth in this Eastern Colony formed in after years the basis for the disreputable suggestion made by some of his numerous enemies to Lord Edward that Lord Fisher was to be distrusted as being a half-caste. As a matter of fact he was of pure English ancestry on both sides, his father having come to Ceylon as *aide-de-camp* to the governor.

Lord Fisher entered the Navy in 1854 as the nominee of the last of Nelson's captains, and saw service in the Baltic and in China. He passed for lieutenant in 1859, gaining the Beaufort Testimonial, which represented to the Navy much what the position of Senior Wrangler did to the mathematical tripos man. In 1863 he was appointed to the Warrior as gunnery lieutenant, and it was here that he first realised the extraordinary conservatism

and lack of insight on the part of those in high places, against which he waged so strenuous a warfare during the whole of his public life. Few, he found, appreciated the fact that the construction of the Warrior rendered every previous vessel and much highly-valued experience entirely obsolete. Lieutenant Fisher realised at once that the war of the future would be an engineers' war. He ventured in short to think for himself, and was fortunate in coming into contact with the little leven of progressive men amongst his superiors. As a consequence he was appointed to the Excellent "for torpedo service," and in 1873, whilst still there, he gave a lecture which had probably a determinative effect on his future career. Amongst his auditors chanced to be one of the Lords of the Admiralty, who was so struck by Commander Fisher's demonstration that mechanical training would in the near future be essential for all officers that he decided "to speak to Goschen about young Fisher." Promotion henceforward was rapid. As chief of the Vernon torpedo school-ship, he carried out much experimental work, gaining experience in matters mechanical, which was greatly enhanced and amplified in later years when, as Admiral Superintendent of Portsmouth Dockyard, he introduced the policy of concentrating work on one vessel at a time, with the result that vessels were launched embodying really recent experience in place of that of years long gone by. In the meantime Lord Fisher had done most valuable work in other appointments. He was president of the 1879 Committee for revising the gunnery manual of the fleet, and so high was his reputation that when the Inflexible was launched, the most powerful and most thoroughly-equipped warship of her day, the command was given to Fisher, although one of the most junior captains. Whilst holding this appointment he fitted out the "armoured train" used in the Egyptian campaign and commanded it in several skirmishes.

Sir Phillip Watts stated at the Institution of Naval Architects last October, that it was whilst in command of the Inflexible that the Dreadnought was first foreshadowed in conversations between Captain Fisher and himself. The proposal was for a ship armed with all big guns (the 80-ton muzzle loaders designed by the War Office which had at that time the monopoly of gun supply for both services), arranged in turrets combining the plans adopted on the Devastation and the Inflexible. Each of these ships had two turrets, but in the Devastation there was one turret forward and the other aft, whilst in the Inflexible there were two turrets arranged *en echelon* amidships. A displacement of 16,000 tons would have been needed, and the suggestion was accordingly considered impracticable by the then chief constructor of the Navy. The matter accordingly remained in abeyance until 1900 when further plans for an all-big-gun ship were got out in consultation with Mr. Gard, the chief constructor at Malta, Admiral Fisher being then in command of the Mediterranean Fleet. But it was only on his appointment as First Sea Lord in 1904 that practical steps were taken which resulted in the launch of the Dreadnought in 1906. This vessel rendered obsolete every existing warship and set back Germany's preparations for war by several years. The naval policy of that country had been based on the consideration that our warships being intended for service in all parts of the world were ill-adapted for service in the shallow waters of the German seaboard. As a consequence it was possible for Germany to build powerfully armed ships suited to her own waters, and yet having all the fuel capacity required for service on the British coasts. The Dreadnought made a change essential, as any effective rivalry involved such a large increase in displacement as to render necessary the deepening of the Kiel Canal and extensive dredging operations elsewhere. It was because of this that Lord Fisher was able to predict that the war with Germany would be in 1914. As a concomitant of the Dreadnought policy Lord Fisher removed from the Navy some 160 vessels, unable either to run or to fight.

Whilst the introduction of the Dreadnought was Lord Fisher's most striking contribution to the material progress of the Navy, he was also responsible in whole or in part for many minor achievements of the same character. He rescued the Navy from its dependence on the War Office for its guns, and thus made possible the enormous improvements in ordnance construction which led to our ships being armed in 1914 with 12-in. and 13·5-in. guns in place of the 11-in. which was the best the enemy could provide. Unfortunately, owing to slackness elsewhere, in the provision of adequate fuses, this superiority of armament was far from fully utilised. Lord Fisher had also much to do with the introduction into the Navy of the Kelvin compass and the water-tube boiler, operated with oil fuel, and later of the steam turbine. He claims also responsibility for the introduction of the Destroyer.

He was the first, too, to realise that the submarine was really the weapon of the stronger navy and not, as too many assumed, of the weaker, but he had great difficulty in making his views prevail, and in his memoirs he gives an amusing account of how he managed to build many more than the Treasury definitely sanctioned. He was of late years a great advocate of the supersession of steam machinery on shipboard by internal-combustion engines, but in proposing, in 1912, the construction of an oil-engined battleship, he was more sanguine than was justified by existing experience. With the knowledge then available it is probable that such a vessel would have been subject to constant breakdowns.

Lord Fisher also did much to improve the standing of engineers in the Navy, and was responsible for the founding of the Osborne School, in which all cadets, in whatever department they proposed to specialise, enjoyed the same training, which was largely engineering in character; but later he recognised that this "common entry" system was unsatisfactory.

When called to office shortly after the outbreak of the war, he worked out an elaborate scheme for the invasion of Germany on the Pommeranian coast, not 100 miles from Berlin. A Russian army was to be landed under cover of the British Fleet, and 612 vessels were ordered for this end, the expenditure being sanctioned it is said by Mr. Lloyd George on half a sheet of notepaper. The Dardanelles expedition caused the diversion of forces intended for this service and, on Lord Fisher's resignation, to the total abandonment of the scheme. He was subsequently appointed head of the inventions Committee, one of the tasks proposed being the extirpation of the submarine menace. In this work, however, the committee received at the outset no effective assistance from the Admiralty, which refused to put at the disposal of the Committee of eminent and exceptionally able men, a submarine for experimental purposes.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page 54.*)

IN our last issue we dealt with the first day's proceedings of the Liverpool summer meeting of the Institution of Naval Architects, and now proceed to a report of the second day.

SAFETY AND THE SUBDIVISION OF SHIPS.

The meeting on Wednesday, the 7th inst., was held in the Lecture Hall of the Central Technical School, and the first paper taken was one entitled "Safety of Life at Sea." It was read by its author, Sir Westcott Abell. Owing to the fact that it dealt with an allied subject the second paper was then read and a combined discussion of the two papers followed. The second paper was entitled "Subdivision of Passenger Vessels." It was also read by its author, Mr. George Webster. Sir Westcott Abell's paper will be found reprinted on page 91 of this issue, and Mr. Webster's on page 94.

Professor J. J. Welch was the first speaker in the discussion. He said he was largely in agreement with the aims of Sir Westcott Abell's paper, but was sorry he could not agree with its methods, or its conclusions. The computation of safety by the "odds-on" for loss method left out of account certain vital factors. This was especially true when it came to questions of variations of permeability. The safety of a one or two-compartment ship was argued on an average calculated permeability, but the actual permeability might be different on particular voyages. One might consider the case of a 600-ft. vessel of 100 ft. floodable length calculated on 60 per cent. permeability. If the bulkheads were 100 ft. apart, the ship would be a one-compartment vessel. If we assumed damage to the ship of 10 per cent. of her length, it would amount to 60 ft. and the "odds-on" for loss would be $\frac{60}{40}$ or $\frac{1\cdot5}{1}$. Assume next that the bulkheads of the same ship were 50 ft. apart, so that she would become a two-compartment vessel. If now she sustained the same damage the "odds-on" for loss would be $\frac{10}{40}$ or $\frac{0\cdot25}{1}$, so that more bulkheads would render the ship safer as, of course, anyone would expect. If an intermediate case was considered, however, with the bulkheads 70 ft. apart, so that the vessel became what one might call a 1½-compartment ship, then if one of the bulkheads was damaged the ship would be lost. In this case the "odds-on" for loss would be $\frac{60}{10}$ or $\frac{6}{1}$, so that on this method of calculation the putting in of more bulkheads had increased the chance of loss by four times.

It was necessary, however, also to take into account the fact that the ship might not have her calculated permeability on any particular voyage. One might consider the cases of the one and the 1½-compartment vessels on the assumption that the permeability was 65 per cent., and work out the relative chances of loss. If the one-compartment ship was pierced in any position she would inevitably founder, and the 1½-compartment ship pierced in the same way would just as inevitably remain afloat. On the other hand, the permeability might be less than the calculated. Assume a permeability of $\frac{7}{10}$ of 60, or 42 per cent., which would apply in the case of, say, a coal cargo. In this case the 1½-compartment ship would become equivalent to a two-compartment ship, and if struck on a bulkhead she would remain afloat. The one-compartment ship struck in the same way would, however, founder. Similarly, if each ship were loaded in accordance with the calculated permeability, but were not floating to their load draughts, the same things would happen.

The matter might be considered a little further. Suppose the bulkheads were 33⅓ ft. apart, so that the vessel became a three-compartment ship and three bulkheads must be damaged before loss occurred. With a 10 per cent. length of damage such a ship would be absolutely safe. Suppose, however, one altered the bulkheads to something a little more than 33⅓ ft. apart, say, 35 ft. The boat would then become something less than a three-compartment ship, and according to the paper would sink if two bulkheads were damaged. The ship would thus be changed from one that was absolutely safe to one that was absolutely unsafe by a slight alteration in the position of the bulkheads. No one would agree that this was true. If it was, then the spacing of bulkheads was a very delicate matter, but he for one did not believe that an alteration of spacing of less than 2 ft. could make this great difference. The "odds-on" method left out of account factors which should be considered, and its conclusions were wanting in completeness and he held that the International Convention made no mistake when it adopted the basis of factorial subdivision.

Professor Welch went on to say that he had already stated that he was in agreement with the aims of Sir Westcott Abell's paper, and he thought, for instance, that the case of the mixed type of vessel carrying relatively few passengers might be reconsidered. The case might possibly be met by a modification of the factor of subdivision which was allowed. Turning to Mr. Webster's paper, Professor Welch referred to it as a very able analysis of the Bulkhead Committee's rules. Mr. Webster appeared to get, by his approximate methods, curves which were substantially in accord with the committee's curves. The question of form was a difficult one, however. In many ocean-going vessels it might possibly be ignored as suggested by Mr. Webster, but it must be remembered that the committee had to consider also cross-Channel

boats and other special craft. On the whole, Mr. Webster's methods would undoubtedly be a very valuable help to designers and he was particularly glad to be able to congratulate him, since he was an old student of his own.

Sir John Biles said the question of the amount of safety of life at sea which could be obtained by subdivision seemed to come down to a matter of chance in the end. Even absolutely positive calculations could never ensure safety, since so many factors came into the problem. Sir Westcott Abell had considered one of the chances which came into the question and had made an effort to measure that chance. His view was new, and all new views tended to widen our information, but he was not sure that the deductions Sir Westcott drew were the last word on the subject. Sir Westcott's attention had been drawn during the war to the subject of damage caused by torpedoes. But if one were to consider the chances of a ship being hit by a torpedo it was necessary to take into consideration the time that was covered by the chances. In times of peace one might well say that there was no chance of a merchant ship being hit by a torpedo, so that in considering this chance fairly not only the damage caused but also the chance of being hit over the whole life of the ship should be taken into account. An obvious reply to this might appear to be that there were other things than torpedoes, and one had to consider, say, icebergs. This was all right, but how many times was a ship hit by an iceberg in the average life of a ship? Another chance that came in was the chance of watertight doors and side lights being left open.

To deduce positive results as Sir Westcott had done one must take all these various chances into consideration. He also could not see the logical basis of the fixed proportion of length for damage which Sir Westcott had worked on. Why should a 600-ft. ship be liable to a larger hole than a 300-ft. ship? He must admit that when he was a member of the Convention Committee he was not a strong adherent of the factorial system, but he had been convinced by other members. He was, however, even now much obliged to Professor Welch for his exposition of the advantages of the factorial system. In conclusion, he might point out that the idea of providing a greater margin of safety in proportion to the number of passengers carried, while all right from the point of view of the community, was not so from the point of view of the individual passenger. The idea, of course, made for larger ships.

Mr. A. T. Wall said that it was quite evident from the papers and the discussion which had so far taken place that the subject was a very controversial one. He had been interested in it from the beginning and had read a paper before the Institution dealing with it. The Bulkhead Committee's rules had met with much opposition, and unfortunately much of this opposition came from people who did not come to the meetings of the Institution to express their views. This applied, for instance, to shipowners and superintendents. It was interesting to remember that Great Britain was the only country which had so far adopted the Convention rules. He had recently talked over the matter with some French authorities, and they had made it clear that they did not at present see their way to full acceptance. The same sort of thing applied to other countries, and Japan, for instance, had not been concerned in this question of subdivision at all. He thought it was beginning to be accepted that the time was ripe for a reconsideration of the whole matter. Sir Westcott Abell had brought forward some strong arguments in favour of his proposals, but, apart from the theoretical considerations, what appealed to him (Mr. Wall) was that on Sir Westcott's method it would be possible to produce ships more economically than on the present factorial system.

On the question of the trouble of the present rules to designers he knew only too much. Professor Welch had said that morning that it was possible to get a variation from the 60 per cent. permeability, and if this was so it altered the whole basis of the rules. Sir John Biles had also talked about watertight doors, but such doors would continue to be fitted in the future and came into the problem. He agreed with Mr. Webster's paper throughout but would point out that practically all his propositions appeared in his (Mr. Wall's) paper of 1915. He thought perhaps Mr. Webster endeavoured to be too accurate. The whole thing must be approximate, and it was not necessary to strive too much for very accurate methods. The whole thing had been carried too far, and what designers wanted was more elbow room. It was quite right to apply their scientific knowledge, but they ought to mix it with a fair measure of practice.

Mr. G. W. Barr said Sir Westcott Abell had referred to the shipping community being faced with the question of the replacement of passenger vessels lost during the war, as it was affected by the International Convention rules. These rules affected all ships the keels of which were laid after December, 1915, and it had become evident, from the point of view of ships of the mixed type, that the rules were unworkable. Old and successful types of ships were apparently to be scrapped or, as an alternative to the alteration of their subdivision, were to be forced to be worked at a reduced draught. This reduction would amount to as much as 3½ ft., representing an average of 2,000 tons of cargo. It was evident that the rules would have to be revised and representations were made to the Board of Trade with that object. The scheme prepared by Sir Westcott Abell and described by him in his paper had been prepared and submitted to the Government. A decision was now awaited. He would like to ask Professor Welch why the Bulkhead Committee had departed from the rules of the 1891 Bulkhead Committee. It was difficult to understand how fewer bulkheads could lead to greater safety, and he thought the old basis was more rational than the factorial treatment. Since the Bulkheads Committee published their report much had been learned, and in view of war experience the time appeared ripe for a reconsideration of the whole matter. In connection with Mr. Webster's paper, he would say that all those who were concerned in design would welcome it as an achievement. When it was realised that a flooding curve could be obtained in less than half an hour and that the error involved was quite nominal, the value of the contribution would be appreciated. A case would certainly appear to have been made out for a simplification of the rules.

Sir Archibald Denny, the last speaker in the discussion, said that in a report by Sir Westcott Abell, which was fairly well known, the following sentence occurred. "It has appeared from the investigations carried out during the war . . . that this factorial method of adjusting subdivision is incorrect in principle and does not allow the risks arising from marine damage to be equally adjusted for different sizes of vessels." He would point out that the International Convention was attended by delegates from 12 Governments and included many noted naval architects, who signed as approving the principle now stated to be incorrect. The investigations made by Sir Westcott during the war were embodied in his Royal Society paper on "Chances of Loss of Merchant Ships,"* and the conclusions arrived at were based upon a presumed radius of damage by explosion of torpedo, or mine, of 20 ft. This may have been an ordinary marine risk of damage during the war, but it was not so now. The ordinary marine risk was piercing the shell of a ship owing to collision with another ship. The ship which was collided with might be damaged in any portion of her length, but the usual damage by end-on collision was not extensive in a longitudinal sense.

Sir Westcott's "odds-on" fell rapidly if the radius was less than 20 ft. He gave an example to the effect that if the radius was 4 ft. less, the "odds-on" were reduced 33 per cent. for a one-compartment vessel 460 ft. long, and 60 per cent. for a similar vessel 340 ft. long. His principle then might well be neglected under ordinary conditions of damage. Sir Archibald went on to say that he did not accept the length laid open as an ordinary marine risk. The Convention came to the conclusion that it was unwise in the public interest to retain the distinctions of one, two and three-compartment ships, and Sir Westcott agreed that a vessel could only be called a compartment ship under certain defined conditions of draught and permeability. Those fixed by the Convention were 80 per cent. to 85 per cent. for machinery space, 95 per cent. for passenger space, and 60 per cent. for general cargo space. The 60 per cent. was arrived at after careful investigation by the British Bulkheads Committee from data supplied by several shipowners, and was confirmed by the Germans, who had for several years been making the same investigations and had come to the conclusion that 61 per cent. to 62 per cent. was a reasonable figure. After all, however, it was only a figure, and to call a ship a one-compartment vessel and then have an accident which only flooded one hold, and yet find the ship sunk like a stone because the permeability of the cargo was at that time greater than 60 per cent. would be much resented by the people on board. This sort of thing was appreciated by the British Bulkhead Committee, and its report said: "The formulation and enforcement of rules governing subdivision is a contribution of the utmost importance to the safety of life at sea, but as regards the result of such rules in any particular case it is not possible to say more than that if the damage does not exceed a specified amount, and if the assumptions made in the rules are not materially departed from, the vessel may be reasonably expected to remain afloat."

We were asked to produce a method which would increase safety of life at sea, not a method which would guarantee that a vessel would not sink if one, two or three-compartments were laid open to the sea. If that had been our charge we would have taken permeability corresponding to an iron cargo, when the figure would have been in the region of 80 per cent. Sir Archibald consequently held that the factorial method was correct, from the point of view that it suppressed the misleading terms one, two and three-compartment ships. There was, however, another aspect of the case. It was true that it was difficult to build small practicable mixed-type vessels unsinkable with one compartment only open to the sea under all conditions of loading, but as the vessels got longer it became practicable, and the factorial system meant that the bulkheads were proportionately more closely spaced as the vessel got longer, and hence at some point she became in fact a real one-compartment unsinkable ship. When the factor was 0·5 Sir Westcott would call the vessel a two-compartment ship, and would say, presumably, that the destruction of one bulkhead would not sink her, but the argument he (Sir Archibald) had just used for one compartment held equally for two compartments. The factorial system meant that the safety of a vessel increased as her length increased without discussion as to the number of compartments which could be flooded.

If reference was made to the paper supplied to the President of the Board of Trade by the Bulkhead Committee in preparation for the Convention it would be seen that they were working in the direction of having a minimum of 3 in. margin after flooding, this margin gradually increasing as the vessel increased in length. The factorial system produced a somewhat similar result, the ships as they became longer floating with a greater and greater margin after bilging. The chance of remaining afloat and navigable after bilging gradually increased whereas with the system Sir Westcott advocated a very large vessel might have her large hold bilged, which would probably be of the full floodable length, and then her margin of safety would be 3 in. only. One must look at the average marine risk, which included navigability after flooding, and whenever possible improve the chances of that means of safety, and this the factorial system did.

It was said to be difficult to reproduce old type ships under the new regulations. But was that ever intended? An attempt was made to increase the safety of life at sea, and there were cases within our knowledge where enormous numbers of passengers were carried in ships which were not even old-style one-compartment ships. The British Bulkheads Committee, before November, 1914, had under consideration a criterion of service which took into account directly the number of passengers, and had the Convention not intervened it might well have been that they would have reported in that sense. The instruction given by the Com-

* See ENGINEERING, vol. cvii, page 420.

mittee to Sir Archibald was that if a suitable occasion arose he should bring that view forward. This meant that an alteration would have been suggested in the old limit of 12 passengers. That limit was, however, fixed by one of the committees of the Convention, of which Sir Archibald was not a member, and when once fixed it was found impossible to have the situation reviewed at that time. The criterion proposed for adoption by the British Bulkhead Committee, using the gross permeability, which included the spaces above the bulkhead deck allocated to passengers, took account of the number of passengers.

Sir Archibald went on to say that he was not fully informed as to the international position. The Convention had not been ratified by all the Powers and there were certain points, this one included, which had to receive special consideration before final ratification. It would be quite in order to raise this point even if it meant an alteration in the definition of a passenger ship, so far as subdivision was concerned. He personally felt that the continuous and regular increase in safety by increase in subdivision would, on the whole, and taking into account ordinary marine damage and the after results thereof, produce a safer ship than the system advocated by Sir Westcott Abell. He thought the public would appreciate candour on this point. It was not possible to eliminate entirely the risks of sea travel and the public was not prepared to pay for a separation of ships into pure cargo and pure passenger carriers. Trade from any new port developed first cargo and very few passengers, probably under 12, and later if the trade was of sufficient importance and the passenger traffic of sufficient magnitude, such as between this country and America, the vessels naturally segregated themselves into pure passenger and practically pure cargo. It was quite in order to call for modifications in the Convention, probably even desirable in view of experience gained during the war, but not on account of conditions prevailing during the war and which had now ceased to exist.

Referring then to Mr. Webster's paper, Sir Archibald said that attempts to simplify the procedure in design by short-cuts had his entire sympathy and praise. From the first he had pleaded for the application of study to the quasi-exact methods produced by the British Bulkheads Committee, so that short-cuts might be arrived at, and in regard to obtaining the first curves of floodable length we owed a debt to Sir Westcott and his staff. Mr. Webster was, as already mentioned, of the staff of Professor Welch which carried out the work for the British Bulkheads Committee. Sir Archibald thought that it was more convenient to obtain the figures from diagrams than from tables by arithmetical interpolation. Mr. Webster had mentioned in regard to shear ratio that he had not carried it to an extreme, apparently because he thought it would be inaccurate, but Sir Archibald pointed out that as the curves concerned were nearly straight it would appear that exterpolation might be employed without much error. Mr. Webster also did not carry his investigations below 0·6 block. Sir Archibald had had this extended to 0·5 block, and quite successfully. The method, thrown into the shape of curves, would be of immense advantage, and Mr. Webster had said frankly that it was based entirely on the work of the British Bulkheads Committee.

In connection with Mr. Webster's method of ascertaining mean permeability, as far as Sir Archibald could see the method quickly produced a result which was probably sufficiently accurate, and one which should be fair as between ship and ship, so long as the vessels were of the same intermediate or similar types. Sir Archibald had tried it for cross-Channel vessels and found it was not applicable, but further investigation might show some similar method to be feasible. Mr. Webster's proposal that the form varieties of the vessel might be neglected he could not agree with. It was true that as far as vertical variation was concerned the effect of the correction usually increased the floodable length because one purposely chooses the worst form. But as far as longitudinal variation was concerned the usual effect was as the floodable length was increased at one end of the vessel it was decreased at the other and large errors of 10 per cent. to 15 per cent. might be introduced. The correction was troublesome to apply, but in order to be fair between ship and ship we had to provide for this. Further study might perhaps discover a simpler method than that laid down, although he was a little doubtful on this point. As far as the difficulties of design were concerned each builder would, for himself, by investigation of vessels he had built of various types, be able to get out rapid first approximations which would enable him to proceed with his design with confidence.

Sir Westcott Abell, replying to the discussion, said that in the time at his disposal he could not deal fully with all the points which had been raised.

He quite admitted that what he had put forward was not a complete solution. It was a solution from a new point of view, from another angle which he thought would be of some value. Sir Archibald had referred to the question of collision risk. He appeared to suggest that this was the main risk to be safeguarded, and for that reason considered the proposed test risk of 10 per cent. of the length as too great. He would observe, however, that the figures indicating safety were only comparative, *i.e.*, they had been applied equally to the Convention system and the proposed scheme, and that with a large variation of length of damage tested down to 2½ per cent., the comparative results were practically unaffected.

Sir Archibald had further stated that the factorial system included the one, two and three-compartment systems, and presumably meant to infer that it must therefore be correct. His (Sir Westcott's) criticism of this system was concerned with the stages between the one and two or between the two and three-compartment positions and his analysis indicated that the chances of loss gradually increase between these particular positions and become very large indeed near the two-compartment stage and near the three-compartment stage. After passing through these stages the chances fell off very suddenly, so much so that, as mentioned in the paper, a small increase in length might make a vessel 10 times safer. He therefore argued that if the factorial system failed under any logical test—and so far he had only been able to suggest one test—it was true to say there must be something wrong in principle. In all previous consideration of the question we had only paid attention mentally to length of damage irrespective of the question of bulkheads. He had contended that since efficiency of subdivision depended on bulkheads it was essential to consider also what risk occurred if a bulkhead was struck. And whereas the factorial system curve as drawn was a comparatively fair curve, and further since the introduction of another bulkhead disturbed the distribution of subdivision, it would appear that a more rational system should proceed by steps, rather than be evenly proportional to length.

Sir John Biles rightly considered that the chances of loss point of view must be taken into account, but did not altogether agree as to the method. He would reply that even if the method was deficient, yet it gave some guidance in estimating the chances, and for that reason tended to help to form our opinions in the proper direction. Here he would like to draw attention to one failing of the Convention system, viz., the provision of a uniform factor of subdivision throughout the length, whereas an elementary calculation would show that for two vessels in collision the odds are roughly, 3 to 1 in favour of damage occurring forward. Subdivision should therefore be closer forward than aft.

Professor Welch's main arguments were based on the fact that in any case the actual conditions as regards permeability would differ from those assumed in calculating the positions of bulkheads. He was quite right in this statement, but he might have added what was equally true that the permeability of a cargo ship was never likely to be the same for any two voyages in the ship's life. He therefore contended that more bulkheads than, say, required for a one-compartment standard would give a bigger margin for contingencies arising from differences of permeability. Sir Westcott's reply was that if an allowance for variation in permeability was required, the right remedy was to provide it directly, and further that this contention took no account of the greater chance loss of bulkheads, since there were more to be damaged.

He would further say that on the evidence given by Professor Welch in his paper of the day before, and on the information ascertained by Mr. Barr, of Messrs. Alfred Holt and Co., contained in Mr. Webster's paper of that day, actual investigation showed that the assumptions made by the Bulkhead Committee did on the "average" obtain in practice. In his opinion all that Professor Welch required was an increased value for permeability to cover variations in actual service. He noticed that Sir Archibald Denny did not answer a very proper question put to Professor Welch by Mr. Barr, viz., why was it that British practice in regard to subdivision which worked excellently up to the time of the Convention—and whose only defect was that it had not been extended to the very large vessels then being built—was discarded entirely in favour of some new theoretical system, the limitations of which were certainly not known. It might possibly be true that for purely passenger vessels the Convention scheme was approximately correct, but the allowance for vessels of the mixed type did not appear to have received sufficient consideration and did not appear to have taken into account the economics of cargo transportation.

Mr. Webster then also replied. He said in reference to Mr. Wall's remarks there were two essential differences in his paper as compared with similar matter in that of Mr. Wall. In connection with floodable length he had introduced the use of freeboard ratio in terms of the depth of the ship instead of in terms of draught, and he had given results in tables which Mr. Wall had given in curves. In connection with Sir Archibald Denny's suggestion for the extension of the sheer ratio curves, he would point out that these might be extended up but not down. This concluded the morning session, and the meeting adjourned.

AFTERNOON VISITS AND DINNER.

On the afternoon of this day, Wednesday, the 7th inst., a visit was paid to Messrs. Lever Brothers soap works at Port Sunlight. A very large number of members and guests took part. Alternative visits were also available to Messrs. Henry Tate and Sons' sugar refinery and the new electric power station of the United Alkali Company at Widnes. In the evening a dinner of the Institution was held at the Midland Adelphi Hotel, Liverpool. The president, the Earl of Durham, presided over a very numerous attendance, and an enjoyable evening was spent. Toasts were proposed or replied to by the President, the Lord Mayor of Liverpool, Mr. Thomas Rome, the chairman of the Mersey Docks and Harbour Board, and Dr. J. C. Adami, the Vice-Chancellor of Liverpool University.

(To be continued.)

NOTES.

POWER FROM SEA WAVES.

IN a paper published in a recent issue of the College of Engineering, Tokio, Mr. I. Hiroi describes some experiments made with a wave motor. He states that taking the coast line of Japan to be 1,500 miles in length, power amounting on the average to at least 5,000,000 h.p. is being wasted in actions which are merely destructive. The above figure is, he states, equivalent to two-thirds h.p. per linear foot of shore, and were it practicable to devise means for utilising it efficiently and without excessive capital expenditure the advantage would be very great. With a view to gaining some idea as to the feasibility of utilising some of the wave energy now wasted he erected within reach of the waves a board, 6½ ft. wide, and suspended from a hinge fixed 18·2 ft. above the lowest point of a bed of concrete, shaped to conform to the path of the lower edge of the swinging board. In order to keep down the cost of the plant the concrete bed was not carried down below low-water mark, its lowest point being in fact 0·8 ft. above mean sea-level. The tides at the site selected have a range of about 5 ft. at springs and 2 ft. at neap tides. The shore is shelving and large waves are broken up at a considerable distance from the shore, and even

in storms the height does not exceed 6 ft. at 1,500 ft. from the shore line where they break. The waves formed as a consequence of this breaking were again broken up at 200 ft. from the shore line. On the other hand even in the calmest weather there are always waves reaching the shore, having a height of about 2 ft., a length of 160 ft. and a period of from 8 seconds to 15 seconds. The pendulum board was loaded with stones, and it was found that the effectiveness of the device varied considerably with the load, but at the best the output was small, the best result being equivalent to the production of mechanical work at the rate of 410 ft.-lb. per second. This was obtained with a pendulum weight of 1,155 lb., a wave height of 2 ft. to 6 ft., with a mean period of 9·8 seconds. The amplitude of the swing ranged from 20·5 deg. to 47·5 deg.

PETROLEUM AND WILD-CATTING.

In the second of the series of lectures arranged by the Institution of Petroleum Technologists, Mr. E. H. Cunningham-Craig, B.A., F.R.S.E., F.G.S., dealt with "Wild-Catting." In America, he said, every well in a new field was a wild cat; over here the term stood for speculation without research. A petroleum geologist could generally be made in three years of hard work, though he never ceased to learn, of course. He had to find out whether a district was petroliferous, why the oil was formed, why it got to a position, and where that position was. One factor at least always remained unknown, and that made the well a wild cat; Mr. Cunningham-Craig himself would not drill when it was four to one against success, though one success far outweighed four failures. There was in Burmah, *e.g.*, a well-defined belt, outside which drilling would be absurd. Barbadoes was lying on the same great circle as the oilfields of Venezuela and Trinidad; nearly all the rocks in Barbadoes below the coral had oil, but few only in quantities promising success, and so far all the wells drilled in Barbadoes had been wild cats. If the yield of oil were to last, there must be an anticlinal or dome structure, and a variation in the position of the well might make all the difference between success and failure. Surface-indications of oil frequently caused wild-catting. North-West Canada had excellent anticlines and good shows of oil; but if the oil came from the basal beds of the crustaceous system, and if those beds had been denuded of the Devonian strata, it would be useless to drill deeply for oil that had never been there. The geologist had also to discover whether there were sufficient porous beds to contain the oil beneath the surface. In the Calgary field, which had seen such a crazy oil boom in 1913, all the essentials seemed to be present, except the porous rock, and the field had been a partial failure at any rate. Above the porous rocks good impervious beds were wanted, and they were missing in some parts of Madagascar, for instance. Even if all geological indications were favourable, the field might belong to the "has beens." New Brunswick and our own county of Derbyshire supplied examples. Though experts had been blamed, the wells recently drilled in England had been located on perfectly sound principles. But there was the danger that the oil had been dissipated through time, absorbed and washed out by water, and that the gas pressure had been lost. The Hardstoft well was far beneath the horizon at which it would possibly be expected to yield oil in quantity; but as luck would have it, a band of filtered petroleum was struck, and he was afraid this happy circumstance had raised too rosy visions. On the whole drilling for oil in England had been a scientific success, but a practical failure. Yet if England had drawn blank, there was still some hopes of Scotland. One of the wild cat wells there at least had chances; that well should have been drilled first, but was actually the last. The moral of all was that wild-catting was a useful thing.

MIDDLESBROUGH PIG-IRON SHIPMENTS. — Messrs. William Jacks and Co., 5, East India-avenue, E.C., state that the shipments from Middlesbrough, including Skinningrove, in June last, were coastwise 32,790 tons, foreign 22,929 tons, a total of 55,719 tons, as compared with 16,310 tons in June last year, and 44,049 tons in June of 1918. In June last there were marked increases in the shipments to Scotland, Wales, Newcastle, France and Belgium.

LITERATURE.

Radio Engineering Principles. By HENRI LAUER, B.S., Associate Member, American Institute of Electrical Engineers and HARRY L. BROWN, B.E.E., formerly Captain, Signal Corps, U.S.A. New York: McGraw-Hill Book Company, Inc.; London: Hill Publishing Company, Limited. [Price 21*s.* net.]

THE object of this book is to explain the processes involved in the methods of wireless communication, with particular reference to those developments which have followed so rapidly on its extensive use in war. It is not a little disappointing therefore, to be informed that by direction of the military authorities, a strict reticence has to be maintained concerning the more notable results and appliances. It is enticing, but useless, to speculate in what direction these sensational extensions have manifested themselves, but we much doubt if any generic discovery or new departure along unexpected lines has been achieved, for the present condition of the science is such, that progress is to be expected as the result of the accumulation of small increments. There is in this case the less inducement to marvel, for the main purpose of the authors is definitely limited to the description of the characteristics and use of the three-electrode vacuum tube in radio telegraphy and telephony, and if we can forget the enforced suppressions, the authors unfold a tale of invention and successful accomplishment of absorbing interest and fascination.

In a few early chapters the general principles governing electrical phenomena are outlined, including the properties of oscillatory circuits. In common with many other writers on the elementary principles of electricity, the authors sketch the atomic theory of matter which seems as much out of place as the discussion of the origin of iron ore would be in a work of marine engineering. Since we only know of the existence of electricity by its effects, the thermionic valve might have been constructed before the detection of the electron, as it certainly was before we learnt that an atom of mercury contains several thousands of electrons, if we know it now. The authors defend the introduction of such matters by contending that the electron theory gives a clearer conception of what takes place under certain conditions, and possibly in considering the electrical behaviour of a heated filament as that in the Fleming glow lamp valve, the electron does assist in visualising the proffered explanation.

The technical portion of the volume begins with the description of the construction of an aerial and the consideration of the directional properties of receiving and transmitting antennæ. The reasoning in the article on the conduction theory of radio communication is not very clear or convincing. The authors appear to regard the sending antenna, the Earth, and the receiving antenna as one single oscillator in which oscillations may be set up. This view is not without strong support, but it does not seem legitimate to omit the effects of reflection from an ionised layer in the upper atmosphere. No account is taken of the influence of wave length, a factor of vital importance in transmitting signals to great distances, and if we have correctly followed the reasoning, wave-length is immaterial. The problem is one that requires all the assistance that mathematics can give, and of this aid the authors have not availed themselves in this section. We remain among those who are startled to find "that for points at a distance greater than one-fourth the circumference of the Earth, the signal strength increases with the distance," so startled indeed that we doubt if we have succeeded in apprehending the precise point on which the authors insist. In a footnote it is admitted that the theory remains open to question or at least has not been submitted to the test of experiment.

With the return to more practical matters the development moves rapidly and surely. Two chapters on damped and undamped wave circuits show the difference and the beneficial effects that would follow from substituting truly continuous waves for intermittent trains of rapidly decadent waves. In the first case of damped waves, methods in actual practice are well explained and the use of coupled circuits in the elimination of interference is put very clearly. The influence of decrement on the sharpness of tuning is shown by appropriate diagrams, and one may easily infer that the higher the decrement the broader the tuning, and the greater the difficulty in eliminating interference due to a highly damped wave. Government regulations in America forbid the use of decrements greater than 0·2, but this factor may require revision as the number of stations increases without limit. In this connection, as shown in the following chapter in undamped waves, the advantages of the heterodyne method of reception become evident. In this system or device, a locally generated, undamped alternating current is superimposed upon the received undamped high frequency alternating current, the two currents differing slightly in frequency. The combination of two such currents gives rise to "beats," similar to those resulting from the combination of two musical notes of almost equal pitch. If a station while receiving signals of a wave-length of 3,000 m., corresponding to a frequency of 100,000 cycles per second, is interrupted by signals from a second source having a wave-length differing by not more than 15 m., elimination by tuning may be ineffective, but if the locally generated frequency is slightly different from either of these values the two sounds heard in the receivers can be made respectively 1,000 and 500 cycles per second, for the desired and interfering signals, two notes that are easily distinguishable by the ear. Another advantage of heterodyne reception is the amplification of the received signal current owing to the generated energy reinforcing that from the transmitting station. Furthermore, the note, being dependent on the frequency of the current generated at the receiving station, can be adjusted by the operator to suit his ear, an advantage denied to damped waves, for the audio frequency is determined wholly by the spark frequency at the transmitting station. Several methods or variations are described for producing undamped waves, a task that long taxed the ingenuity of electricians. The instruments described are the Alexanderson and Goldschmidt alternators, suitable for use in permanent stations where extremely accurate speed control can be maintained, the Poulsen arc with which it is possible to obtain frequencies of 2,000,000 or 3,000,000 cycles per second and of great amplitude; the oscillating arcs which will give undamped oscillations by purely electrical means, that is no combination of electricity with mechanism is necessary: and the three electrode vacuum tube oscillator.

Attention is mainly centred in the last-named device with its numerous applications as detector, oscillator, and modulator. So much has been written of late on the construction of this apparatus that it is not necessary to say more than that, while the thermionic value as originally designed by Professor Fleming consists of an arrangement which will ensure the passage of electrons from a glowing filament to a plate in the same exhausted bulb, in the three-electrode tube, the emission of the stream of electrons is controlled by the potential of an auxiliary grid electrode. This third electrode takes the form of a perforated plate, or mesh of fine wires, inserted between the filament and the plate, and its function is to control the current in the plate circuit without changing the plate potential or the filament temperature. When used as a detector the complete apparatus displays its superiority over other detectors by amplifying the signals, thus increasing the sensitiveness of the instrument very materially. This amplifying action the authors consider very fully, together with its further development in the form of cascade amplification, of which several arrangements are described. Of a special design used by the American Signal Corps, the amplification reaches as high a value as 60,000. No doubt very weak signals from distant stations can be reproduced with great strength, but such large numbers as these must be determined theoretically and their practical significance is difficult to estimate. Amplification does not exhaust the usefulness of the tube; it can be put to many other purposes which are fully explained, and these chapters will be found as pleasant to read as they are instructive in material.

The section on radio telephony might have been extended, especially in the description of the ferro-magnetic methods of modulation, a comparatively

recent plan for amplifying the variable resistance reaction of an ordinary microphone transmitter. The remarks on multiplex radiotelephony are suggestive and hopeful; elimination methods will call for much examination in the future, and the methods finally adopted will probably differ greatly from those indicated here. The book concludes with a description of some methods and apparatus that have rendered eminent service to navigation, and permitted the localisation of positions of unseen objects. Some others might have been given, but perhaps the military authorities have imposed limits to the diffusion of information on practical applications. Throughout the volume, however, there is an air of freshness and suggestiveness which will ensure for the book a ready welcome from a large class of readers.

BOOKS RECEIVED.

Labour, Capital and Finance: Essays on the Great Problems of the Day. By "Spectator" (WALTER W. WALL, F.J.I., F.S.S.). London: Sir Isaac Pitman and Sons, Limited. [Price 3s. 6d. net.]

Pithead and Factory Baths. By EDGAR R. CHAPPELL and J. A. LOVAT FRASER. Cardiff: Welsh Housing and Development Association. [Price 2s. net.]

A National System of Education; Some Recommendations for Establishing it in England during the Decade ending Ten Years hence. Manchester: University Press; London: Longmans, Green and Co. [Price 1s. net.]

Transactions of the Institution of Water Engineers, with (Contents and Subject Index, Vols. I to XXIV). Vol. XXIV, 1919. Edited by PERCY GRIFFITH, M.Inst.C.E., F.G.S. London: St. Bride's Press, Limited.

Pyrometry: A Practical Treatise on the Measurement of High Temperatures. By CHAS. R. DARLING. Second edition, revised and enlarged. London: E. and F. N. Spon, Limited. [Price 10s. 6d. net.]

Modern History of Warships: Comprising a Discussion of Present Standpoint and Recent War Experiences. By WILLIAM HOVGAARD. London: E. and F. N. Spon, Limited. [Price 42s. net.]

Surveying. By W. NORMAN THOMAS, M.Sc., B.Sc. London: Edward Arnold. [Price 31s. 6d. net.]

Mercantile Year Book and Directory of Exporters. 1920. Edited by WALTER LINDLEY-JONES, F.R.G.S. London: Lindley-Jones and Brother. [Price 20s. net.]

Ministère de L'Industrie, du Travail et du Ravitaillement Recensement de L'Industrie et du Commerce (31 *Décembre*, 1910), *Vol. VII.* Bruxelles: J. Lebèque and Cie.

Economic Liberty. By HAROLD COX. London: Longmans, Green and Co. [Price 7s. 6d. net.]

The Elements of Electro-Technics. By A. P. YOUNG, O.B.E., M.I.E.E. London: Sir Isaac Pitman and Sons, Limited. [Price 7s. 6d. net.]

Highway Inspectors' Handbook. By Prévost HUBBARD. First edition. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 15s. net.]

An Elementary Treatise on Differential Equations and their Applications. By H. T. H. PIAGGIO, M.A., D.Sc. London: G. Bell and Sons, Limited. [Price 12s.]

THE LATE MR. JAMES WEIR.

WE much regret to learn of the death, on the 10th inst., at his residence—Over Courance, near Lockerbie—of Mr. James Weir, one of the founders and for many years head of the well-known Glasgow firm of auxiliary engine and pump manufacturers. In this capacity he did most useful experimental work, having been endowed by Nature with highly practical yet inventive facilities. These were associated in him much more than in other inventors, with shrewd commonsense and indomitable energy, so that he achieved a large measure of commercial as well as engineering reputation.

Mr. Weir was in his seventy-eighth year, having been born in 1839 at Blackburn, Linlithgowshire. His father died when he was 6½ years old, and his mother, a woman of strong personality and character, then removed to Glasgow. In 1858 he entered the office of Messrs. Hamilton and Grandison, consulting engineers and machinery agents, Exchange-square, Glasgow. This firm were the agents for Silver's marine governor. Mr. Weir carefully studied this apparatus, which had been found not altogether satisfactory under certain conditions, and he came to the conclusion that instead of an improvement on the principle embodied in Silver's governor, an entirely new type was required. In 1860 he embarked on his career as an engineer, starting his apprenticeship with Messrs. Randolph and Elder. While employed by that firm he worked at the designing of a new governor which would be free from the defects of the Silver type, and later on took out a patent for his design. A governor was made for him by Messrs. Smith Brothers and Co., Canning-street, Glasgow, and he obtained liberty from Messrs. Randolph and Elder, during the last year of his apprenticeship, to go to Messrs. Smith Brothers and Co. to supervise the construction and fitting up of the governor. The original governor was fitted on ss. Garland, belonging to Messrs. Cameron, of Glasgow (later Alexander Laird and Co.), plying between Glasgow and Sligo. It is interesting to note that this governor was taken from the ship and exhibited at a *conversazione* of the Institution of Engineers and Shipbuilders in Scotland during the presidency of Mr. J. MacQuorn-Rankine. The apparatus was well-known and extensively used in the mercantile marine until the introduction of the triple-expansion engine, when the necessity for an apparatus of this type gradually ceased. During his apprenticeship he studied at the Glasgow Mechanics Institute, and on becoming a journeyman, served for some time as an outside foreman. Wishing to get some sea-going experience he joined Messrs. John Ribby and Co., of Liverpool, with whom he served in different grades up to chief engineer, sailing to the Mediterranean, Spain and Oporto.

In 1870 he commenced business as a consulting engineer, first in Liverpool, and later in Glasgow, where he was joined by his brother George, and the firm became Messrs. G. and J. Weir. The office was in Hydepark-street, Glasgow. By this time he had patented many useful inventions, among which were the well-known automatic starting valves for ensuring the starting and handling of compound engines, the hydrokineter, and several types of feed heaters. The firm were superintending engineers for Messrs. Gardner

Photo. by Lafayette.

THE LATE MR. JAMES WEIR.

and Co., Glasgow, and Messrs. Rankine and Son, Grangemouth. They had also a close connection with China through Mr. Weir's younger brother, Mr. Thomas Weir, who was superintendent engineer for the China Merchants Steam Navigation Company, Shanghai, for which company Messrs. Weir supervised the design and building of many vessels on the Clyde and elsewhere. The offices of the firm were removed first to Jamaica-street, and later to Commerce-street, Glasgow.

During this time Mr. Weir was attracted to the matter of corrosion in marine boilers, and began a long series of researches on this subject, the results of which are recognised as having been of great practical and scientific value. His experiments and investigations on the question extended over a number of years, and were conducted on a large, practical scale before he ventured to put forward his results and their method of application. It may be said, indeed, that this serves to demonstrate a highly characteristic trait to be found throughout all Mr. Weir's work, namely, that only after exhaustive trial, and when he was himself satisfied that his result was correct, did he ask the engineering world to adopt his views. The ultimate outcome of his corrosion researches was the Weir marine feed heater, which not only established the Weir principle of feed heating as the most economical method, but also rendered the feed water treated by it innocuous and non-corrosive. At this time, however, the boilers of steamships were fed by feed pumps worked from the main engines, and it was found that these main-engine pumps were incapable of dealing with the feed water in the condition it left the feed heater. Mr. Weir then applied himself to securing a feed pump independent of the main engines, which would be suitable for the new conditions imposed by the feed heater. After visiting the United States—then the home of the duplex direct-acting pump—and investigating the qualifications of the various type there for his purpose, he concluded that none of the existing designs were entirely suitable. He then concentrated his attention on the design and construction of a new pump, which would meet the requirements of dealing with hot water from the feed heater and be suitable for the higher boiler pressures which were then being rapidly adopted.

The Weir automatically-controlled feed pump was the result, and, in conjunction with the heater, it formed the feed heating and feeding system now so widely associated with his name. The late Mr. Peter Denny, of Dumbarton, was a good friend to the inventor during the evolution of his system, and, together with Mr. Walter Brock, his partner, was impressed with the value of the scheme, and at once adopted it in vessels under their construction. The merits of the system were soon generally recognised, and although at first the gear was made by various firms, the demand soon became sufficiently large to necessitate a special establishment for its manufacture, and in 1887 new works were erected at Cathcart, in the vicinity of Glasgow. It is significant of Mr. Weir's foresight that at a time when specialisation in engineering was much less in vogue than it is now, the new works should have been laid down and designed solely for the production of the Weir specialities. Shortly after the establishment of his new works the necessity for the use of fresh water for feed make-up purposes in high-pressure boilers was recognised by Mr. Weir, and he was the first to place on the market an evaporator for the mercantile marine. The advantages of this apparatus were recognised by the Admiralty, and it was adopted by H.M. Navy and fitted to a large number of warships. The original evaporators were fitted in conjunction with Normandy distilling condensers, but later the Weir distilling condenser was developed, and now Mr. Weir's firm furnishes complete distilling plants for naval purposes.

The introduction of the water-tube boiler in the Navy created a number of new problems in auxiliary machinery, and a demand arose for a special type of feed pump for the new generator. By careful experiments on actual boilers erected for the purpose, the Weir high-pressure boiler feed pump was produced, and has been adopted almost exclusively for the feeding of the various types of water-tube boilers in H.M. Navy. Mr. Weir's association with naval boiler practice, not only in the British Navy, but in foreign navies, led him to devote a considerable time over a period of years to the investigation of water-tube boiler problems. His views on this subject are to be found in his paper on "The Problem of Combustion in Water-tube Boilers," read before the Institution of Engineers and Shipbuilders in Scotland at the summer meeting at Sheffield in 1899. The business of Mr. Weir's firm was, in 1891, converted into a limited liability company, of which he was the first chairman. His brother, Mr. George Weir, retired from the business immediately after its conversion.

Mr. Weir has never been much of a publicist; but he was one of the founders and a vice-president of the Institute of Marine Engineers, London, and a member of the Institution of Naval Architects; he was for some time a member of the council of the Institution of Engineers and Shipbuilders in Scotland. The leisure moments which his energy permitted him were devoted chiefly to scientific questions and investigations. His excursions into the domain of physical science have borne fruit in two small volumes, "Terrestrial Energy" and "Steam-Engine Efficiency," both distinguished by a characteristic originality of view and disregard of accepted traditions. In a larger volume, "The Energy System of Matter," published by Messrs. Longmans, Green and Co., in 1912, Mr. Weir still further amplified and discussed the thesis of his earlier books. At the International Engineering Congress at Chicago in 1893, Mr. Weir presented a paper on "Boiler Feeding," embodying the results of his experiments in this department of engineering.

Mr. Weir withdrew from active participation in his firm's business in 1910, and retired to Dumfriesshire, where he has interested himself in agricultural pursuits. It is characteristic of the man that he should devote himself to farming with the same assiduity and thoroughness that he displayed in tackling engineering problems. He carried out, in conjunction with the West of Scotland Agricultural College, a series of experiments in land reclamation and cropping which have given highly interesting and successful results. Whether regarded as an observant and resourceful inventor, or as a prudent experienced, enterprising man of business, few can fail, when the originality and scope of his work is considered, to admit his possession of unique and commanding powers, both as a man and as an engineer.

MESSRS. RUSTON AND HORNSBY'S WORKS, LINCOLN: ERRATUM.—We much regret that by a typographical error in line 36, of the first column of page 5 of our issue of the 2nd inst., the date at which Messrs. Richard Hornsby and Sons acquired the Ackroyd-Stuart oil engine patents was given as "1901" instead of "1891."

AN INFINITELY VARIABLE MECHANICAL GEAR.

THE design of a positive mechanical gear which could be varied by infinitely small stages within the limits of its capacity, instead of merely in definite steps like the ordinary gear of a motor car has long been a problem offering much attraction. The same end has, of course, long ago been achieved by various electrical and hydraulic appliances, but the possibility of producing a purely mechanical appliance with these properties certainly is of interest to any mechanical engineer. We know of a gallant major who, before the war, spent much time and money on this problem, and we fear he was far from the first or last to do so.

A solution to the problem now appears to have been arrived at by Mr. Francis J. Healey, and a demonstration of his gear was given on the 14th inst. at the Shepherd's Bush works of British Universal Variable Gears, Limited. We understand that this company has purchased a large war factory for the purpose of carrying out the manufacture of the gear. The office of the company is at 35, King-street, Cheapside, E.C. 2. The Healey gear is claimed to be suitable for almost any of the purposes for which mechanical gearing is now used, of which, for instance, motor-car work and machine tool driving are specially mentioned. The gear is of the chain type. In its simplest form it consists of two parallel shafts each carrying a sprocket wheel which is capable of being expanded or contracted in diameter. A control lever operates the expanding and contracting mechanism of both wheels together, so that as one becomes larger in diameter the other gets smaller. An endless chain connects the two sprockets and, owing to the relation which is maintained between their diameters, always remains taut. It will be clear that the arrangement in a sense resembles the well-known expanding cone belt drive, but since it employs a chain it is a truly positive gear. Evidently a sprocket wheel cannot be expanded by arranging that each tooth shall move outwards radially since, with any method of this kind, it would be impossible to maintain pitch. In the Healey gear the teeth are formed in sets of three machined solid together. These sets nest together side by side and form a complete wheel at the smallest diameter. As the sprocket is expanded the sets move apart and a wheel with gaps between each set of three teeth is formed. There are about eight sets of teeth to a wheel and they are mounted on blocks which slide in and out in slots formed in two faceplates, which form the sides of a complete wheel.

It will further be evident that the arrangement even as we have now described it will not maintain pitch. The three teeth in a block will always remain at the correct pitch of the chain, but the relation between the different blocks will only be such as to agree with the pitch of the chain at certain positions. To overcome this the sets of three teeth are arranged to have a slight circumferential movement on the blocks which carry them, so that if their outward radial position is such that they normally would not be in pitch they can move sideways and accommodate themselves to the chain. The tooth sets can only drive, or take the drive, when they are hard-up against the block which is carried in the faceplate slots, and the effect is that in anything except selected positions only one set of teeth will be driving, or be driven, and the remainder will be floating. The question naturally occurs why, at any radial position of the blocks, there should be any set of teeth in a position to take the drive, and why all should not be geometrically out of pitch and have to adjust themselves circumferentially. We appealed to Mr. Healey on this point, and he told us that it would take us a week to understand it. This was not very helpful. As, however, it was the only enlightenment we got, we are driven to an explanation of our own for the action of the gear.

It would appear that such a position as we have suggested is a possible one, and that, say, on a sudden change of gear the sprocket may find itself in the position that no tooth is in a position to take up the drive. This state of affairs is clearly an impossible one for driving, and presumably what occurs is that the chain lags until some one set of teeth comes against its driving block and takes up the work. The same action apparently takes place on the driven wheel, but whether the momentary cessation of drive which must take place on gear changing leads to jar we cannot say. It will probably appear from our description that the gear contains a large number of small parts and is, in common phrase, "a box of tricks." This idea is, however, unjust to the arrangement, which is very neatly worked out and appears to be quite a practicable contrivance. It should perhaps be mentioned that the teeth are cut to suit the smallest diameter of the sprocket, so that when it is expanded the outer tooth of each set of three are not engaged by the chain to their full depth. The arrangement, however, appears to run very well.

INDUSTRIAL NOTES.

At the annual conference of the Miners' Federation of Great Britain, held in Leamington last week, the following resolution, which we outlined on page 48 *ante*, was agreed to: "That this Conference makes a demand upon the Government for the immediate reduction of 14*s.* 2*d.* per ton in the price of domestic coal, and for an advance in wages of 2*s.* per day flat rate for all members of the Federation over the age of 18, of 1*s.* per day for those between the ages of 18 and 16, and of 9*d.* per day for those below 16. The proposal for an alteration in the constitution of the Federation was dropped, finding no seconder. The proposal to give power to the Executive Committee to call a strike without a ballot of the members was defeated. Five days a week policy: This proposal was withdrawn at the present time in the interests of the country. It was also decided to take steps to abolish what was known as the 'butty' system."

The following resolution, moved by Mr. Hartshorn, M.P., was also passed: "That this Conference, having examined the terms of the Ministry of Mines Bill, hereby decides to refuse to operate it should it become law, and urges the Labour Party to use every means at its disposal to prevent its passage through the House." In this connection, Mr. Smillie added that the Government and coal owners ought to know, in the event of the Bill becoming law, that the federation would be bound to assist any district in any group by a general strike to prevent any reduction in wages. It was proposed to set up under the Bill a system which would make reductions in wages in some districts inevitable, and that would certainly be followed by a general strike of the Miners' Federation. The Government, when they realised this, surely could not proceed with the Bill.

A special Trades Union Congress was held at the Central Hall, Westminster, when Mr. F. Hodges moved, on behalf of the Miners' Federation, a resolution "protesting against the British military domination of Ireland, demanding the withdrawal of all British troops from that country, the cessation of the production of munitions of war destined to be used against Ireland and Russia; in case the Government refused these demands, recommending a general down-tools policy; and calling on all the trade unions represented to carry out that policy, each according to its own constitution, by taking a ballot of its members or otherwise." On a card vote, the result was, in favour of the miners' resolution 2,760,000; against 1,636,000; majority in favour 1,124,000.

At the same special Trades Union Congress referred to above, Mr. C. T. Cramp moved a resolution on behalf of the National Union of Railwaymen, also dealing with Irish affairs, when there voted for the resolution 1,953,000, against 1,759,000; majority for 194,000.

The annual congress of the National Union of Railwaymen which was held at Belfast last week decided by a majority of 42 to 18 votes, after a discussion which was held in public, to accept the recent award of the National Wages Board. We dealt with this award on pages 789 and 855 of our last volume. The following resolution was then moved, and carried unanimously: "That the Conference reaffirms the previous decisions in favour of nationalisation of the railways, and decides that any attempt by the Government to allow the pre-war system to become operative will receive the most strenuous opposition." It was stated in connection with this resolution that the public had been misled as to the object of the railwaymen; these had in view not their own benefit but that of the community as a whole. They were persuaded from long experience that not only would the railways be better managed under co-ordinate administration, but that the wicked and wanton waste of the past administration would be avoided. They were not to be misled by any such scheme as that of the Ministry of Transport. Nationalisation was of vital interest to the trade and commerce of the country.

In the course of one of the meetings in Belfast, Mr. Bromley, secretary of the Associated Society of Locomotive Engineers and Firemen, conveyed the greetings of his society to the National Union of Railwaymen, and expressed the hope that the two bodies would continue in the future to work more closely together than in the past.

In the meantime the Minister of Transport has informed the Rates Advisory Committee that since the issue of his directions last December to the railway companies of the United Kingdom to increase their charges, it was estimated that the financial result of working British railways (including Ireland) would show a deficiency as from April 1, 1920, at the rate of 54,500,000*l.* per annum, this total including increases of 4,400,000*l.* in salaries and wages which came into force on July 1, under the provisions of the sliding scale.

An unauthorised strike of Manchester gas workers, numbering 1,200, against the award recorded in our last issue, was declared on Thursday, the 8th inst., and the movement spread to other cities, causing a great deal of inconvenience to firms who depend upon the gas supply for running their machinery. The object was to mark the men's dissatisfaction with the 6*s.* advance in wages granted them by the award, instead of the 10*s.* they claimed. In regard to the situation, Mr. J. R. Clynes, M.P., president of the National Union of General Workers, is reported to have stated that the union viewed with great regret this stoppage of work on the part of the gas workers; it was a revolt against the union, which had done its best in the men's interest. In a later message to the men, Mr. Clynes expressed the hope that the men would now regard the strike as a protest made under provocation, and, having made their protest, they would at once resume work without pressure from any quarter and ask their representatives to continue negotiations. He suggested that a few additional representatives be appointed by the men to act in any further conference with the employers which might be convened to discuss questions not yet settled to the men's satisfaction. He was satisfied that the men could not secure any better terms by an unauthorised strike, and they could only secure trade union and public support by acting for the time being according to the terms arranged on their behalf by the appointed representatives. By remaining out now the men would lose more than the margin of gain between the concession and their demands.

Mr. Clynes went to Manchester last Monday and discussed the situation with the men, but failed then to prevail on them to return to work. He succeeded on Wednesday, and the Chairman of the Gas Committee has promised to arrange for the reconsideration of the workers' claims.

The exhibition of work by disabled ex-service men in training under the Ministry of Labour scheme will be opened on the 21st inst., at 11 a.m., at the Central Hall, Westminster. In this connection, the Ministry of Labour state that 22,781 men have been trained, 24,285 men are in training, and 23,626 are waiting to be trained. There are, moreover, 23,605 disabled men who, to-day, are asking for work. In the solution of the problem, the Ministry ask the wholehearted co-operation of all sections of the community as a duty.

Since the announcement in our last issue of the settlement in the printing trade dispute, fresh trouble has arisen. Manchester and Liverpool members of the Typographical Association now claim—besides the 10*s.* per week advance granted to the trade as from June 12—a further bonus of 10*s.* per week. This demand was considered by a meeting of the employers' representatives held in Manchester, which invited the Executive of the Typographical Association to confer with them to discuss the action of their branches. The employers also asked if the Executive thought it desirable for the association to confer with the eastern branches. The Executive replied that this was not desirable, and informed the employers that they had advised the branches to withdraw their application. Notices appeared in the Manchester newspapers on Saturday last that overtime would not be worked in any offices of that area, excepting where the 10*s.* bonus had been conceded. The master printers complain that this action was taken without due notice being given. No overtime has been worked in the area during this week. The situation is considered serious. On Friday last the employers asked for an assurance that the Executive would take steps to prevent a stoppage, and as no reply had been received, the ultimatum threatening the discharge of members of the Association was despatched last Tuesday.

ELECTRIC UNDERGROUND RAILWAY IN MADRID.—Since last autumn an electric underground railway, 4·5 km. in length, has been running in Madrid, probably the only town in Europe of less than 1,000,000 inhabitants which possesses an underground service. The line is double track, 1,445 mm. gauge, and runs from the Puerto de Sol north to Cuatro Caminos, there being six intermediate stations. The system is direct current of 550 volts. The 11 motor carriages are equipped with two motors of 175 h.p.; all the carriages are built of iron. A continuation of the line to the southern station is in progress. Electric railways are so far very scarce in Spain. There are some mining railways, one from Gergal to Santa Fé, 22 km. long, three-phase; another mining railway in the Rio Tinto district, 45 km., also three-phase, is under construction; and there are further some light railways, from Barcelona to Sabadell and Manresa, 10·5 km., the Pamplona-Sanguesa line of 61 km. and the Sebastian-Hendaya line, of 20 km., both alternating current of 6,000 volts. On the main railway lines electric traction has not yet been adopted, but it will come with the development of the national hydro-electric power scheme to which we recently referred.

SAFETY OF LIFE AT SEA. *

By Sir WESTCOTT ABELL, K.B.E., M.Eng., Member of Council.

THE question of safety of life at sea is, from its very nature, conjectural in that no standard of safety has as yet been set up, and if it should be possible to do so, such a standard can only be relative and can have no absolute value. It is certainly true that a vessel can be designed to float to meet a particular case of damage; *e.g.*, to withstand a longitudinal underwater tear of, say, 40 ft. in length at any part. On the other hand, it is fairly certain that such a precaution will involve economic disability and unless the remedy falls within what may be termed economic limits, the price of travel will be unduly high and the tendency be to confine passenger traffic to more and more specialised vessels, thus again increasing the cost of transport. It becomes fairly obvious, when all the various ills to which a ship is liable are borne in mind, that any consistent regulations can only be drawn up from the formulation of "average" rather than "particular" risks. This is a difficult question owing to the variety of causes which may occasion loss, and consequently, whatever risk is assumed must bear a fairly constant relation to the size and other properties of the vessels under consideration. Further, while on this question it must be generally remembered that legislation is mainly based on abnormal and particular accidents and that its equable bearing to all classes of casualty is only slowly and subsequently brought into effect. Public opinion is therefore generally against the policy of safeguards against "average" losses, and in choosing a standard care must be taken that it has such a form as is conveniently logical and readily understood.

Suppose for a moment that it is possible to establish some sort of criterion of risk to apply to a particular case and that, for the sake of argument, the "odds on" for loss of this vessel carrying, say, 1,000 passengers are unity, then, in order to make the safety of life the same for the same vessel carrying, say, 2,000 passengers, the arrangements should be such that the "odds on" for loss of ship are reduced to one-half. It would thus appear possible, once a fair criterion of risk is obtained, to extend it fairly so that against average casualties the chance of escape should be the same for every passenger carried, which is a step forward in the right direction. It must, however, be observed that so far only the safety of the vessel has been considered, and when a particular case arises, as is always likely, in which the average chance is exceeded the vessel is lost and means extraneous to the vessel itself have to be taken to save as many lives as possible. This brings in the vexed question of life-saving appliances which are necessarily somewhat imperfect and liable to many risks of damage. The question of transferring a large number of passengers to flotation apparatus is no easy matter in calm weather under the most favourable circumstances, and its aspect under average conditions at sea is certainly a formidable one, to say nothing of the difficulties of manœuvring and landing on a rocky shore in heavy weather.

Without entering into a detailed discussion, it is evident that the statutory requirements for life-saving appliances as at present framed serve one object for which apparently they were not intended, viz., for a given size of ship they place a superior limit on the number of passengers that can be carried. And, curiously enough, these are about the only regulations on the subject for the existing provisions for subdivision contain only a slight check on numbers of people, with the consequence that with very similar vessels there is a wide difference in the chances of safety per passenger carried. A stage further in the argument has now been reached, and it may be assumed that a state of affairs has been achieved under which it is possible to set down some standard of safety in relation to the size of vessel and the number of passengers carried, and also that it may be possible to adjust the standard of safety for the same ship with varying number of passengers. The ideal solution thus becomes possible, and if all ships were exposed to the same, or similar, risks, and worked on similar routes, and the passengers had similar chances of ultimate rescue in case of total loss, it would be practicable to frame administrative regulations which could be applied equitably in all directions. But, of course, such conditions do not apply equally; the circumstances attending passenger transportation in the North Atlantic between Europe and the United States are much more favourable to safety than those obtaining elsewhere, and are widely different from those in the traffic, say, between South Africa and Australia. Consequently, there should be a realisation of these differences, and, on reflection, there is an economic check tending to equalise affairs. Vessels operating on a scattered and extended route carrying relatively few passengers per mile run per year, are more subject to seasonal variations of travel and are obliged, for very existence, to depend partly or largely, on cargoes as well as passengers. Economic limitations in the more extended trade routes therefore for a given size of ship tend to reduce the numbers carried in comparison with more congested areas, and thus tend to improve the chances of safety of life.

It would consequently appear that an approximation to regulations for safety of life should take cognisance of: (*a*) The size of ship, (*b*) the number of passengers carried, and (*c*) the economic circumstances which obtain. The third condition is of vital importance, since, if world trade is to be cheap, it must be large; if it is to be large, people must travel; people will travel if facilities are cheap, and therefore trade will grow. Not only therefore is travel necessary, but the cheaper the transportation, the greater the trade of the world, and further, the peace of the world tends to be fostered, since people are better messengers than letters, just as letters are less liable to misunderstanding than cablegrams. No scheme of regulations which are purely technical can therefore be likely to succeed, for the chances are as likely as not that they will tax out of existence the slower cargo vessel carrying few passengers, and harden the line between the purely passenger and the purely cargo types. The proper solution begins to be approached when economic conditions are considered and included in some measureable fashion. With all this discussion of the problem, many of the facts have been omitted, and necessarily so, for whatever solution is adopted, it must, from its very nature, be arbitrary and the condition to be aimed at is to obtain a solution which is approximately and relatively true.

The second phase of the inquiry begins with the idea of having some sort of test risk which can be applied fairly to all sorts of vessels as a measure of the chance of loss likely to be experienced. Loss may arise from collision with another vessel, with a sunken derelict, or with an iceberg; from stranding (observing that vessels have on several occasions torn out the bottom on a reef of rocks, subsequently sliding off into deep water), from leakage arising from defective openings under water or near the load line, or perhaps from damage caused in heavy weather, from lack of stability when exposed to heavy storms and high seas (although the number of cases directly traceable to this cause are comparatively few and such as there are may be complicated by the presence of water free to move, arising from some previous leakage), and lastly, cases of loss have occurred, and must continue to happen, from fire. Now, in all these cases, except the last, the ultimate casualty is mainly due to loss of buoyancy caused by the entry of water into the ship, and consequently it would appear that to represent average cases of damage, the proposed measure of risk must take the form of assuming some damage to the hull of the vessel, and the suggestion that at once arises is that some constant percentage of the length of the vessel would appear to give an approximate measure of marine risk.

It may of course be argued—and for that matter every point so far discussed is arguable, as it should be—that a constant percentage of the length will not take account of the variation in speed of vessels and of many other factors that may arise, but, on the other hand, there are bound to occur many variations from average conditions, and considering average risk, such constant percentage approximates to the truth and is fair as between different sizes of ship. Cases will always arise where a big ship cuts a small one in two, and no subdivision rules whatever could meet such a contingency. Further, since longitudinal damage is most destructive as regards loss of buoyancy, the criterion of risk should be measured longitudinally and under water. It would therefore appear that a first examination with a view to produce equitable regulations should be made by means of a "criterion of risk" which involves a longitudinal under-water tear extending for a constant percentage of the length of the vessel. The exact percentage is a matter of indifference, since the problem is one of relativity, and therefore the figure taken may be such as would embody in simple form the chances of loss of a given well-known type of vessel.

For example, in the case of the 400-ft. standard vessels built during the war to carry about 8,000 tons of cargo and subdivided so that any one compartment could be open to the sea when exposed to a damage of 10 per cent. of the length (40 ft. is about the average longitudinal extent of torpedo damage) the "odds on" for loss of vessel are 1 to 1. This seems a convenient starting point, as these vessels were designed as far as possible to suit economic conditions of perhaps a rather specialised form. To put this basic standard into a more concise form, it might be taken that: "For a 400-ft. cargo vessel loaded to the maximum permissible draught and subdivided to comply with a one-compartment standard, the "odds on" for loss of ship, when exposed to a longitudinal underwater damage of 10 per cent. of the length of the vessel are as 1 to 1." It remains for the first approximation to connect the safety of the vessel with safety of life carried, and for simplicity of conception, it may be desirable to connect numbers of passengers with length of vessel. For, in view of the present regulations for life-saving appliances, the number of passengers is regulated by the deck area, and as the ratio of breadth to length is a fairly constant one, the number is regulated sufficiently nearly by the length alone.

An examination of various classes of ships shows that the number of passengers carried per foot of length varies from 5 in the highest class of North Atlantic liner to 2 in the intermediate class of the same service, and in the first-class vessels for the Eastern trade (largely cargo), while there are many vessels carrying a few passengers in which the ratio is less than 1. As a rough guide it may be taken that passenger vessels may carry as many as five passengers per foot run of length, while for intermediate vessels carrying cargo as well, a fair average would be two, and there are many cases with one only.

The standard risk requires to be associated in some way with numbers of passengers, and further allowance should be made in order that with the same length of vessel the protection given, *i.e.*, the "odds on" for loss, can be adjusted inversely as the number of passengers carried. There are, however, certain difficulties which require much consideration, for as there is a higher limit to economic restrictions and as these restrictions are already at a maximum value somewhere about 400 ft. length of cargo ship, it follows that as the length of ship increases, bulkheads can, relatively to length, be spaced more closely, and further that as longer ships can be made safer intrinsically, there should be a reduction in the "odds on" for loss of ship as the length increases, and this quite independently of the number of passengers carried.

The next phase is to consider the "mixed" type of ship (*i.e.*, vessels carrying mainly cargo and few passengers) loading to the maximum permissible draught and starting from the "odds on" for loss of 1 to 1 for 400 ft. length of ship, to devise a basis standard of safety for various lengths. For reasons which will appear later it is desirable for administrative, as well as theoretical, purposes to step the various changes in length rather than to adopt a standard directly proportional to length, and on these conclusions, supposing that all passengers are carried above the deck to which the bulkheads extend (termed the "bulkhead deck") it would appear that the economic limitations are met fairly by the following values of standard of safety:—

Range of Lengths.	Average "Odds On" for Loss.	Types of Subdivision.
Feet.	Ratio to Unity.	
410 to 440	1·0	I
440 to 480	0·835	II
480 to 510	0·67	III
510 to 540	0·53	IV
540 to 570	0·41	V
570 to 600	0·31	VI
600 to 650	0·20	VII
650 to 700	0·10	VIII

The Roman numerals indicating the type of subdivision are arranged so that each increase in number means increased subdivision.

While this basic table of "odds on" for loss of vessel may be deemed to be satisfactory for ships of the "mixed" type, yet it is obvious that for equality of treatment in regard to safety of life, such a scale requires to be associated with a certain number of passengers per foot run of length, and that means should be devised for vessels of the same length to give increased subdivision with a larger number of passengers. Such an elaboration of the scale can no doubt be formulated, but as the principal object at present is to direct attention to the question of subdivision for the "mixed" type of vessel, this broader aspect must be left over for future inquiry.

JUSTIFICATION OF THE PROPOSED STANDARD OF SAFETY.

The hypothetical standard of safety discussed previously has not as yet received any justification, and while it appears perfectly easy to set down some arbitrary numbers and empirical methods of subdivision, yet the connection of such numbers with existing conditions needs to be established. The first step towards this idea was taken during the war, when it was necessary at various times to consider the protection of merchantmen against submarine attack. It became apparent that to make cargo vessels safe against torpedo attack, it would be necessary to introduce so many bulkheads that the vessel's use would be very limited as a cargo carrier, and consequently that more ships would be required for the same amount of transportation. It was estimated, from several points of view, that the loss of carrying power (as compared with the ordinary cargo steamer subdivided so as to remain afloat when any one compartment was open to the sea) involved in protection against one torpedo explosion would approximate to as much as 20 per cent., and further it had to be remembered that such vessels could be damaged, which might result in a loss of six months' service owing to the extent of the destruction caused by a torpedo and to the great demand on the limited facilities for repairs, limited both as regards labour and plant.

In fact it was considered, in the spring of 1917, owing to the various disabilities of the more protected vessel, that if the construction of such types was proceeded with, some two and a half to three years would have elapsed before the more protected vessels had brought into this country the same quantity of goods as could have been carried by the one-compartment vessel, taking into consideration rate of new construction, rate of sinking and rate of repair and replacement, but ignoring the increased difficulties in loading and unloading. Under such conditions it became necessary to try to reduce what was deemed a matter of opinion to a form of calculation, and a first attempt was made to estimate the "odds on" for loss of vessel when exposed to a longitudinal "rent" of some 40 ft.*

Suppose, taking as before the case of the 400-ft. standard ship with a one-compartment standard of flotation, that the main holds were some 65 ft. in length, it is obvious that in any one compartment the vessel would remain afloat as long as the centre of explosion was more than 20 ft. from a bulkhead. There is thus an area of 25 ft. in the middle of length of hold where a torpedo can explode without causing loss of ship, and it was seen that for a first approximation the test of safety was the "odds on" for loss of one bulkhead which, in this particular case, works out at 40/25 or 1·6 to 1. Of course, this argument was only true for one hold, but it was subsequently found possible to extend the calculation to the whole ship by considering the safe and dangerous areas for each bulkhead, summing up for the whole vessel and expressing "odds on" as the ratio of dangerous to safe areas. The idea was further pursued, in view of its possible application to the question of the subdivision of passenger vessels, until, in 1918, it

* Paper read before the Institution of Naval Architects, July 7, 1920.

* See in Appendix, summary of paper on "Chances of Loss of Merchant Ships," by Sir W. S. Abell, Proc. Roy. Soc., A, vol. xcv, page 671.

was found possible to extend the computation to calculate the "odds on" for loss of two and three consecutive bulkheads, thus enabling cases to be considered in which vessels were designed to float with two or three adjacent compartments open to the sea (for details see paper summarised in Appendix).

The second phase of development began in the spring of 1919 when the shipowning community, faced with the difficulty of replacing the great number of passenger vessels sunk during the war, began to give very earnest consideration to the restrictions of the Convention for Safety of Life at Sea, which had concluded the first part of its labours in the early part of 1914. It was found that these new regulations imposed such disabilities on the intermediate class of passenger vessels, carrying small numbers of people and with cargo below the bulkhead deck, that they would be practically driven out of existence and the pre-war facilities for cheap access to all parts of the world would have to be much curtailed and the cost of transportation, already much higher on account of increased wages and cost of vessel, would be very much enhanced in the intermediate type of ship as compared with the passenger vessel. Beyond this, also, in many cases, the restrictions placed on cargo carriage were such as to make the transport of many classes of commodities almost impossible, with the consequence that the main earning freight was considerably curtailed. It became apparent therefore that the operation of the Convention had seriously curtailed the use of intermediate passenger vessels and had, in fact, taken insufficient account of the economic requirements, quite apart from the restriction on trade caused by the increased difficulty and cost of world travel. Under these circumstances the shipowning community made representation to the British Government of these disabilities on world commerce and caused investigation to be made of the requirements for subdivision, with the result that an alternative solution was put forward which, while giving practically the same safety of ship as required by the Convention, yet took better account of the economic requirements of the intermediate vessel. This alternative scheme substituted for the Convention system of subdivision an arrangement which was a combination of the "one-compartment" and "two-compartment" ideas, the fundamental basis being that for vessels of the "mixed" type (i.e., carrying mainly cargo and relatively few passengers) the vessel of 400 ft. in length should have a one-compartment standard throughout and that the two-compartment requirement should be gradually introduced until, at about 600 ft. in length, the standard of subdivision should be entirely "two-compartment."

It is obvious that with such an arrangement, extra subdivision could only be introduced in steps, consequently for every 30 ft. or 40 ft. increase in length, additional subdivision was introduced on the basis that increased protection was more desirable first at the ends then in the machinery space, and more particularly forward than aft.

This arrangement was then compared with the Convention requirements, and it was found possible to attain practically the same standard of safety (as determined by the method already described in brief) as was obtained under the existing regulations, and further that in some respects there was a distinct improvement in the better location of "danger areas."

To facilitate the consideration of this scheme, it will be as well to indicate in tabular form the various gradings of subdivision between the "one" and "two" compartment standards (see table in the preceding column.)

For the "mixed" type of vessel, the scheme of subdivision put forward was as follows :—

Length (Feet).	Type of Subdivision.	Average "Odds On" for Loss of Vessel.	
		New Scheme.	Convention.
410–440	I	1·0 to 1·0	1·0 to 1·0
440–480	II	0·83 to 1·0	1·0 to 1·0
480–510	III	0·67 to 1·0	1·0 to 1·0
510–540	IV	0·53 to 1·0	0·8 to 1·0
540–570	V	0·41 to 1·0	0·4 to 1·0
570–600	VIII	0·10 to 1·0	0·10 to 1·0

It will be observed that there is a sudden decrease in the "odds on" for loss at 570 ft. and that the gradation of subdivision suddenly jumps at that length from V to VIII. The reason of this is because the Convention introduces at apparently some arbitrary length a requirement for the two-compartment standard which at once largely increases the chances of safety—in fact it was the observance of such a large increase in safety brought about by the adoption of a two-compartment standard which first suggested that the Convention method of determining subdivision contained some error in principle. It will be observed from the "odds on" column in the table above that the safety has improved ten times between 510 ft. and 570 ft. in length which, on the face of it, seems absolutely out of proportion to possible variation in number of passengers carried. If it be possible, and no reason is seen to the contrary, it would be rational to extend the above table to read somewhat as follows :—

Length (Feet).	Type of Subdivision.	Average "Odds On" for Loss of Vessel.	
		New Scheme.	Convention.
410–440	I	1·0 to 1·0	1·0 to 1·0
440–480	II	0·83 to 1·0	1·0 to 1·0
480–510	III	0·67 to 1·0	1·0 to 1·0
510–540	IV	0·53 to 1·0	0·8 to 1·0
540–570	V	0·41 to 1·0	0·4 to 1·0
570–600	VI	0·31 to 1·0	0·1 to 1·0
600–650	VII	0·20 to 1·0	0·0 to 1·0
650–700	VIII	0·10 to 1·0	0·0 to 1·0

The proposed scheme is certainly more rational, and gives better grading than is contained under present regulations, in fact, it agrees with the Convention, when the arbitrary kinks are faired out and, as already stated, the modification is preferable as regards location of danger areas (Figs. 1 and 2). Considerable justification has therefore been shown for the adoption of the new scheme as an alternative requirement for the "mixed" type of vessel. If it is to be made clear, however, that the standard of safety is not a directly calculable quantity and must vary to some extent with special conditions, e.g., it can only be a strictly comparable quantity when the length and arrangements of the ship are such that every bulkhead is so situated as to be in the position affected by combining the "one" and "two" compartment standards in different ways, and that protection is regarded as more important forward than aft. It is not known to what extent the Bulkhead Committee of 1891 took economic requirements into account, but certainly a system which had received considerable attention and was regarded as satisfactory for a certain stage of development, might have been taken as a basis for departure, when, owing to improvement in design and increase in size, some alteration in procedure was required.

The other method was originally proposed by the International Convention, and subsequently adopted in a modified form by the recent Bulkhead Committee. In this method, a "permissible length" of compartment is used which is derived from the floodable length by a multiplying factor which gradually decreases, as the length of vessel increases, from a maximum value of 1·00 at 295 ft. length to 0·34 at 899 ft. length for vessels of the "mixed" type.

In order to make a fair comparison between the two alternative systems of subdivision, some connection between them is necessary and, for that purpose, some kind of definition is required. In a particular region of the vessel it may be said that for compliance with a "one-compartment," "two-compartment" or "three-compartment" standard respectively, the vessel should remain afloat with one or two adjacent or three adjacent compartments open to the sea. For a constant type of vessel, each of these three standards is naturally associated with a particular length of ship, and the recent Board of Trade regulations for the "mixed" type give the following figures :—

One compartment standard, 295 ft., say 300 ft.
Two-compartment standard, 571 ft., say 600 ft.
Three-compartment standard, 899 ft., say 900 ft.

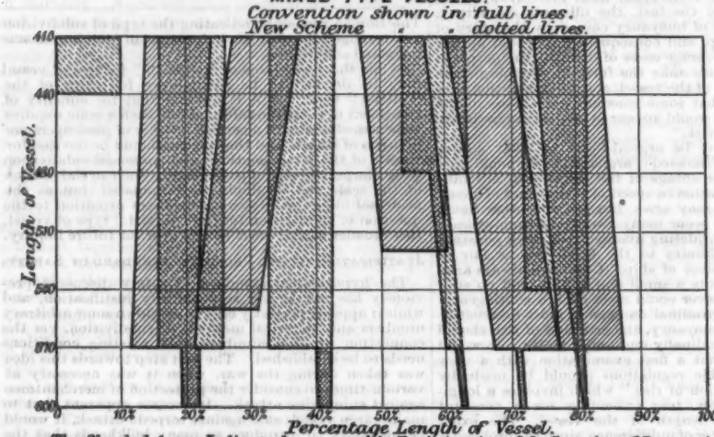
As the object of this inquiry is to obtain some proper relation between safety and economic requirements, it is necessary to translate these figures into length of hold space. For a "three-island" type of cargo steamer with normal sheer and the minimum freeboard permitted by the Load Line Regulations, and only carrying passengers above the upper deck, the minimum length of holds occurring at about quarter-length from either end of the vessel would be approximately 40 ft., 60 ft. and 70 ft. for the 300 ft., 600 ft. and 900 ft. length of vessel respectively. As these holds are very short for general cargo purposes, it would be necessary to increase the freeboard,

Table of Subdivision.

(The Figs. 1 and 2 indicate a One-and Two-compartment Standard Subdivision respectively.)

Type of Subdivision.	After Peak and After Hold.	After Holds.		Machinery Space and Reserve Bunker or Deep Tanks.	Forward Holds.		Fore Peak and No. 1 Hold.
		Two Aftermost.	Other.		Aft of No. 2 Hold.	No. 1 and 2 Holds.	
I	1	1	1	1	1	1	1
II	1	1	1	1	1	1	2
III	1	1	1	2	1	1	2
IV	1	1	1	2	1	1	2
V	2	1	1	2	1	2	2
VI	2	1	1	2	2	2	2
VII	2	2	1	2	2	2	2
VIII	2	2	2	2	2	2	2

Fig. 1. DIAGRAM SHOWING COMPARATIVE DANGER AREAS. MIXED TYPE VESSELS.

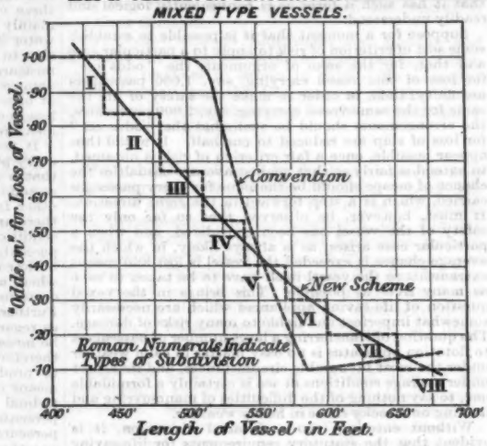


The Shaded Areas Indicate the Positions at which 10% Damage would cause the Loss of the Vessel.

An Examination of the Location of Danger Areas shows that with the New Scheme these Areas are more evenly distributed than with the Convention Regulations, thus Improving the chances of Survival.

(6418.K)

Fig. 2. COMPARISON BETWEEN VALUES FOR "ODDS ON" LOSS OF VESSEL FOR CONVENTION AND NEW SCHEME. MIXED TYPE VESSELS.



Systems of Subdivision.

It has already been suggested that the present scheme of subdivision as embodied in the Convention has various demerits as compared with a system which involves combinations of what may be termed "one-compartment" and "two-compartment" standards. Moreover, it is to be observed that the latter arrangement is in accord with history, since it is contained in the report of the Bulkhead Committee of 1891 in the following form :—

First Grade.—Flotation with any two adjoining compartments open to the sea.

Second Grade.—Flotation with any two adjoining forward compartments or any one after compartment open to the sea.

Third Grade.—Flotation with any two of the three foremost compartments or any one other compartment open to the sea.

Fourth Grade.—Flotation with the two foremost compartments or any one other compartment open to the sea.

Fifth Grade.—Flotation with any one compartment open to the sea.

Sixth Grade.—Flotation with any one forward compartment open to the sea.

It will be seen that the variation in subdivision is

and such increase of freeboard is the simplest measure of the price to be paid for a higher standard of subdivision.

The investigations made during the war on the flotability of cargo ships, and applied particularly to the standard vessels, showed that :—

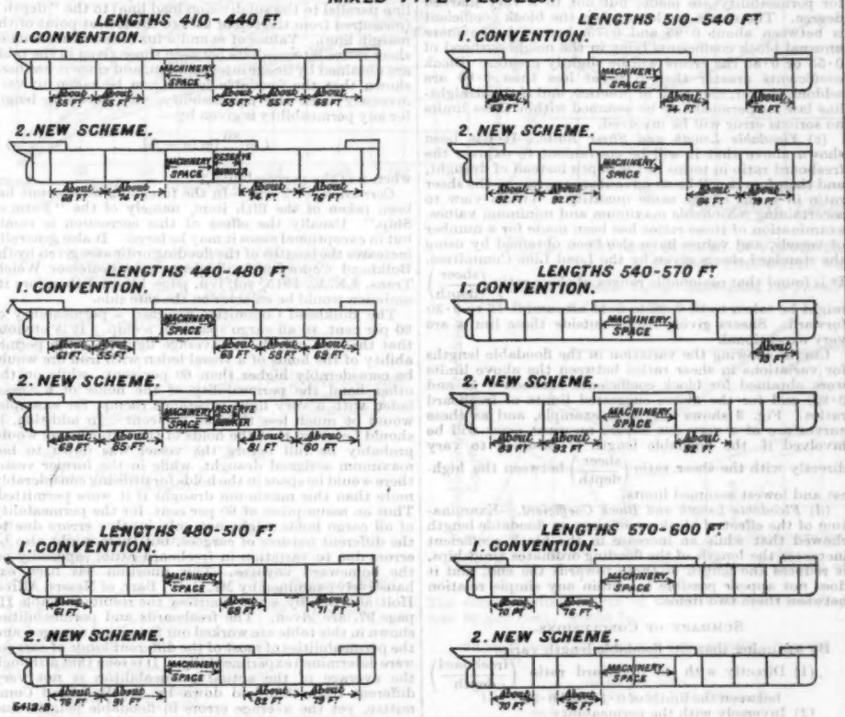
1. It was possible to comply with the "one-compartment" standard of subdivision in vessels of 400 ft. in length by fitting seven bulkheads and by restricting the maximum length of hold to about 69 ft.

2. In order to obtain a "two-compartment" standard with the same vessel, it would be necessary to increase the freeboard to an extent which would sacrifice about 1,500 tons deadweight, and also to fit nine bulkheads, reducing the shortest hold to about 44ft. in length, and

3. It was almost impossible to comply with a "one-compartment" standard for vessels below about 385 ft. in length without increase of freeboard, and with seven bulkheads in place of the six usually fitted.

It would appear, as the result of the war investigations and their subsequent developments already referred to, that the system of the Convention which employs a gradually decreasing fraction of the floodable length is incorrect in principle and that there is no rational adjustment of chances of loss in relation to different sizes of vessel. Further, to illustrate this point, the case of a

Fig. 3. TYPICAL ARRANGEMENT OF BULKHEADS WITH SUBDIVISION AS REQUIRED BY CONVENTION AND BY NEW SCHEME. DRAUGHT AS PER TABLE "A" OF FREEBOARD TABLES THROUGHOUT. MIXED TYPE VESSELS.



6413-B.

vessel with bulkheads arranged to suit the "one-compartment" standard of subdivision might be considered, and it might be assumed that another bulkhead was introduced, the hold spaces being reduced in length proportionately, the freeboard remaining the same. Further, since the length of damage liable to be sustained from marine causes is considered to be directly related to the length of vessel, it may be further assumed that the vessel would be exposed to the same chance of damage with the two different arrangements of bulkheads.

In the case of the "one-compartment" vessel with one additional bulkhead, the ship would float, when damaged, with an increased freeboard as compared with the "one-compartment" vessel as long as only spaces between bulkheads are open to the sea. If, however, a bulkhead is destroyed, either of the vessels will sink, and since the probable length of damage is the same for the two cases, it follows that the chances of loss of a bulkhead, which is the chance of loss of the ship, gradually increases until the increased number of bulkheads added is sufficient to enable the "two-compartment" standard to be complied with. The same argument applies also to variations of subdivision between a "two-compartment" and a "three-compartment" standard.

The same conclusion might be put in another way by saying that starting from the one-compartment standard, the "odds on" for loss continuously and more rapidly increases until the two-compartment standard is reached, when there is a sudden and very rapid fall to very low "odds," while the same conclusions hold for stages intermediate between the "two" and "three" compartment standards.

A numerical example of the relative safety of different degrees of subdivision is perhaps instructive and for that purpose, a vessel, in which the floodable length is 100 ft., is assumed to be exposed to damage which extends 60 ft. lengthwise. For a "one-compartment" standard, the "odds on" for loss of a bulkhead are as 1·5 to 1, whereas, if the bulkheads are spaced, say, 70 ft. apart, the odds have increased to 6 to 1 for loss of a bulkhead, i.e., for loss of ship. If, however, the bulkheads are spaced 50 ft. apart, i.e., a "two-compartment" standard is obtained, the "odds on" for loss of ship, i.e., of two bulkheads are reduced to 0·25 to 1, while on the other hand, if the bulkheads are spaced still more closely, say, 35 ft. apart, the "odds on" for loss of two bulkheads would be increased ten times, or would be 2·5 to 1. Considerations such as these certainly indicate that in order to equalise the risks as between ship and ship, the factorial system of subdivision appears to be incorrect, and that for passenger vessels, the better method is a combination of the "one-compartment" and "two-compartment" standards.

General Remarks.

The suggestions put forward in this paper may perhaps be summarised, for the purpose of discussion, as follows:—

1. The factorial system of subdivision is incorrect in principle, and very small changes in the size of vessel may give rise to large increases in the risk of loss.

2. The scheme of subdivision more in accord with history consisting of combinations of the "one" and "two" compartment standards can be arranged (*a*) to give a rational system and a graduated increase of safety with increase of length, (*b*) to give a better standard of safety than is contained in the present regulations, (*c*) to be capable of adjustment for variation in numbers of passengers carried, and (*d*) to meet reasonably the economic requirements of cargo transportation.

It may be observed that the proposed scheme has been applied to a considerable number of vessels belonging to various companies, which were considered to be those most likely to be affected by the present regulations for the "mixed" type of vessel, and such vessels were chosen from those found by owners to be the most economical types under actual service conditions. Further, it was possible, through the courtesy of one of the big shipping firms, to examine the whole passenger-carrying fleet of the company in the light of the proposed procedure. It would appear, therefore, that sufficient evidence has been obtained to support the contention that the proposed scheme reasonably meets the requirements of ship economics.

In order to illustrate some of the points mentioned, Figs. 1, 2 and 3 have been attached, which indicate :—

1. A comparison between the safety and danger areas of the two schemes for varying length with an assumed damage of 10 per cent. of length of vessel (Fig. 1).

2. A diagram (Fig. 2) indicating a comparison of the average "odds on" for loss of the "mixed" type of vessel with variation in length as given by the proposed scheme and by the present regulations, and

3. Length of hold in various lengths of vessels under the present regulations and under the proposed scheme (Fig. 3).

Reference should be made here to a most important point in connection with the calculations necessary to determine subdivision—which, under present conditions are troublesome, and suggestions have already been put forward to the Board of Trade with a view to modification. This question is, however, being dealt with in a second paper by Mr. G. Webster, M.Sc., who has been my assistant throughout all these investigations, and to whom I am considerably indebted in every way for the work that has been done in considering so difficult a question.

APPENDIX.

BRIEF SUMMARY OF PAPER ON "CHANCES OF LOSS OF MERCHANT SHIPS," BY SIR W. S. ABELL, K.B.E., FROM THE PROCEEDINGS OF THE ROYAL SOCIETY, A, VOL. XCV, 1919 (see page 5).

It may be assumed that the intactness of watertight subdivision will be destroyed within some horizontal radius R of the centre of a fixed and reasonable length of damage.

1. Where the bulkhead spacing is $(2R + a)$, the "odds on" for loss of one bulkhead are $\frac{2R}{a}$. If the centre of damage is at a distance R from the bulkhead, the intactness is destroyed, and within a space $(2R + a)$ bounded by a bulkhead at each end the horizontal length within the vessel which may be injured without damaging a bulkhead is a and the length where the contrary effect is produced is 2 R. When $(2R + a)$ is great, compared with 2 R the "odds on" loss are small, but as $(2R + a)$ decreases the "odds on" rapidly increase until, where the spacing is within about 15 per cent. greater than 2 R, the rate of increase of odds is extremely rapid and becomes nearly infinite when the spacing is nearly 2 R. It is therefore important that the spacing of the bulkheads should be greater than $1{\cdot}15 \times 2R$.

2. Where the bulkhead spacing is $(2R - a)$ one bulkhead will be damaged in every instance, it is therefore necessary to calculate the chances that two bulkheads will be destroyed by the assumed length of damage and the "odds on" will be $\frac{a}{2R - 2a}$. As in case (1) it is desirable to avoid spacing bulkheads lying between 1·15 R and R in order to confine probability of loss within reasonable limits, but it may be noted that in this case where the spacing = 2 R, the "odds on" for loss for two bulkheads are zero.

3. Where the bulkhead spacing is $(R - a)$ two bulkheads will always be destroyed, therefore the probability of damaging three bulkheads must be determined in this case and will be represented by $\frac{2a}{R - 3a}$, with approximate limitations as in the previous case that spacing between $1{\cdot}15\ \frac{(2R)}{3}$ and $\frac{2R}{3}$ should be avoided.

The deductions which may be drawn from the application of the above results to actual vessels of constant type are :—

(*a*) For a given standard of subdivision decrease of size of a large vessel only slightly increases the chances of loss.

(*b*) For small vessels the risk of loss is relatively high, and it is doubtful whether any transverse system of subdivision is effective for vessels below 320 ft. in length.

(*c*) There is considerable increase in safety with increase in length of vessel.

(*d*) The addition of intermediate bulkheads is of more value in larger vessels but may, in some cases, increase risk of loss.

CHLORINE ABSORPTION BY CHARCOAL. CARBON MONOXIDE.—Charcoal has been found to be one of the most generally useful absorbents for poison gases and is very largely utilised therefore in gas masks. When charcoal is exposed to chlorine, two processes take place. Carbon is absorbed or adsorbed, and owing to the presence of moisture—which can hardly be excluded—hydrochloric acid is formed, the carbon itself acting as catalyser. The adsorptive capacity of the charcoal is limited, moreover, and after a certain time, known as the service period, either chlorine or hydrochloric acid will appear in the gas given off. The length of the service period depends upon the density of the charcoal, the thickness of the layer and the amount of moisture in the charcoal, and these factors also decide whether chlorine itself, or hydrochloric acid will appear first. Investigating these problems in layers up to 10 cm. thick at various temperature and gas pressures, G. S. Bohart and E. Q. Adams (Journal American Chemical Society, 1920, pages 523 to 544) find that when the gas is half saturated with moisture the service period is a minimum when chlorine and air are mixed in the ratio of 500 to 1. The different samples of charcoal varied enormously in their efficiency. Below 12·5 deg. C. chlorine is generally the first gas to escape, above that temperature hydrochloric acid; both may be retained for 850 minutes and more. The gas pressure is of little influence. While on this subject we should also add that the "hypocalite I" which seems to be the most effective absorbent for carbon monoxide, consists of 50 parts of manganese dioxide, 30 of copper oxide, 15 of cobalt oxide Co_3O_4, and 5 of silver oxide. According to A. B. Lamb, W. C. Bray and J. C. W. Frazer (Journal of Industrial and Engineering Chemistry, 1920, pages 213 to 221) the granular mixture of these oxides removes more than 90 per cent. of CO from a mixture of carbon monoxide and air of 25 per cent. and acts for an indefinite period, when the air is dry; damp air should be dried by calcium chloride, and the life of the hypocalite then depends upon the efficiency of the calcium chloride.

SUBDIVISION OF PASSENGER VESSELS.*

By Mr. GEORGE WEBSTER, M.Sc., Member.

THE method of obtaining the subdivision of passenger vessels proposed by the Bulkhead Committee and adopted by the Board of Trade has received much adverse criticism. Objections have been raised not only to the intricate and laborious nature of the calculations, especially the "correction for form," but also to their indirect character. The permissible draught of a ship can seldom be obtained by one calculation, and generally has to be obtained by "trial and error," which means repeating the calculations two or three times. In addition, further time is taken up by the Board of Trade in examining the calculations. Great advantage would therefore be gained if a simpler, quicker, and more direct method of obtaining the flooding curve for a ship could be devised.

With this object in view, it is necessary to consider the variables which affect the flooding calculations. The floodable length l at any point in the ship has been shown by the Bulkhead Committee to be dependent upon—

(1) Freeboard ratio $= \frac{\text{freeboard}}{\text{draught}}$.
(2) Permeability.
(3) Sheer ratio $= \frac{\text{sheer}}{\text{draught}}$.
(4) Block coefficient.
(5) Form of ship.
(6) Length of ship.

If the floodable length is expressed as a percentage of the length of the ship, item (6) disappears. Of the remaining five variables, the last one—i.e., "form of ship"—is the most difficult to take account of, and if this could be omitted the problem would be considerably simplified. The standard curves prepared by the Bulkhead Committee take account of the first four of these variables, and introduce the "correction for form" as a modification to the results obtained from the curves. The work would be simplified further if the freeboard and sheer ratios could be expressed in terms of the known quantity depth instead of the unknown quantity draught. It is now necessary to examine the effect on the floodable length of variations in each of the above variables.

(*a*) *Floodable Length and Freeboard Ratio.*—A series of cross curves of floodable length on a base of freeboard ratio $\left(\frac{\text{freeboard}}{\text{draught}}\right)$ were obtained from the Bulkhead Committee's standard curves, and a similar series on a base of $\frac{\text{freeboard}}{\text{depth}}$ were also plotted. The curves are somewhat of the form shown in Fig. 1. For freeboard ratios greater than 0·20 the curves are of a very flat nature, especially if plotted on a base of $\frac{\text{freeboard}}{\text{depth}}$, when they approach very nearly to straight lines. Consequently, if the floodable length be assumed to vary directly with $\frac{\text{freeboard}}{\text{depth}}$, no great error will be involved, and whatever small error there is, it will be less than would be incurred if the floodable length was taken to vary directly with $\frac{\text{freeboard}}{\text{draught}}$.

The freeboard ratios of a number of vessels were examined, and it was found that values of $\frac{\text{freeboard}}{\text{depth}}$ less than 0·18 or greater than 0·38 (equivalent to $\frac{\text{freeboard}}{\text{draught}}$ of 0·219 and 0·613) are seldom, if ever, met with in practice. It therefore appears that the floodable length can, without very great error, be assumed to vary directly with the freeboard ratio, provided the latter is expressed in terms of the depth instead of the draught $\left(i.e., \frac{\text{freeboard}}{\text{depth}}\right)$ and is within the above-mentioned limits.

(*b*) *Floodable Length and Permeability.*—The standard curves already referred to, prepared by the Bulkhead Committee, give floodable lengths for two extreme permeabilities—viz., 60 per cent. and 100 per cent. Floodable lengths for intermediate permeabilities are obtained by assuming that the differences in floodable lengths between the two sets of curves vary in the inverse ratio of the differences in the permeabilities. For example, if l_1 and l_2 be the floodable lengths for permeabilities of 60 per cent. and 100 per cent. respectively, then the floodable length l_u for any permeability u intermediate between 60 per cent. and 100 per cent. is given by—

$$l_u = l_2 + \left[\left(l_1 - l_2 \right) \frac{\left(\frac{1}{u} - \frac{1}{100} \right)}{\left(\frac{1}{60} - \frac{1}{100} \right)} \right]$$

A reduction in labour would be obtained if the results could be derived from one set of diagrams instead of two. This might be arranged if the floodable length can be assumed to vary inversely with the permeability. Then

$$l_u = l_1 \times \frac{60}{u}$$

or

$$l_u = l_2 \times \frac{100}{u}$$

Investigations of a number of cases have been made in order to ascertain the error involved when this assumption is made. Fig. 2 is a typical example, the full curves giving the floodable lengths for 60 per cent. permeability being obtained direct from the Bulkhead Committee's diagrams. The dotted curves give approximate floodable lengths for 60 per cent. permeability, and were obtained by assuming the floodable lengths to vary inversely with the permeability between 80 per cent. and 60 per cent.—i.e., the floodable lengths for 80 per cent. permeability were obtained from the Bulkhead Committee's diagrams and were modified in the ratio of 80 to 60. It is seen that towards the ends of the ships the approximate method gives results which are less than the actual (*i.e.*, they err on the safe side), while towards amidships there is practically no difference in the two curves. Consequently, since the permeability in the majority of ships lies between about 65 per cent. and 85 per cent., and since freeboard ratios $\left(\frac{\text{freeboard}}{\text{draught}}\right)$ much greater than 0·40 are unusual, it is seen that no great error will be introduced if flooding ordinates for 80 per cent. permeability only are given, and floodable lengths for any other permeability are obtained by modifying these given ordinates in the inverse ratio of the permeabilities. The permeability of machinery spaces is laid down by the Bulkhead Committee to be 80 per cent. (except in motor vessels, when it is 85 per cent.), and thus the midship portion of the flooding curve can be obtained very quickly if, as proposed, 80 per cent. is adopted as the basis permeability. Block coefficient, to some extent, affects the errors involved, when the above assumptions for permeability are made, but not to a very marked degree. The errors are least when the block coefficient is between about 0·65 and 0·75, but with the more unusual block coefficients lying in the neighbourhood of 0·55 or 0·85 the errors will be slightly greater. Block coefficients greater than 0·80 or less than 0·60 are seldom, if ever, met with in practice, and if the straight-line law for permeability be assumed within these limits no serious error will be involved.

(*c*) *Floodable Length and Sheer Ratio.*—It has been shown above that it will be convenient to express the freeboard ratio in terms of the depth instead of draught, and therefore it will be an advantage to express the sheer ratio in terms of the same quantity. With a view to ascertaining reasonable maximum and minimum values, examination of these ratios has been made for a number of vessels, and values have also been obtained by using the standard sheers given by the Load Line Committee. It is found that reasonable ranges of sheer ratio $\left(\frac{\text{sheer}}{\text{depth}}\right)$ might be taken to be 0·08 to 0·15 aft, and 0·16 to 0·30 forward. Sheers giving ratios outside these limits are very exceptional.

Curves showing the variation in the floodable lengths for variations in sheer ratios between the above limits were obtained for block coefficients between 0·55 and 0·85, and for the above suggested limits of freeboard ratios. Fig. 3 shows a typical example, and as these curves are of a very flat nature no great error will be involved if the floodable length is assumed to vary directly with the sheer ratio $\left(\frac{\text{sheer}}{\text{depth}}\right)$ between the highest and lowest assumed limits.

(*d*) *Floodable Length and Block Coefficient.*—Examination of the effect of block co-efficient on floodable length showed that while an increase in the block coefficient increases the length of the flooding ordinates amidships, it reduces the length of these towards the end, and it does not appear possible to obtain any simple relation between these two items.

SUMMARY OF CONCLUSIONS.

By assuming that the floodable length varies—

(1) Directly with the freeboard ratio $\left(\frac{\text{freeboard}}{\text{depth}}\right)$ between the limits of 0·18 and 0·38;
(2) Inversely with the permeability;
(3) Directly with the sheer ratio $\left(\frac{\text{sheer}}{\text{depth}}\right)$ between the limits of 0·08 and 0·15 aft, and 0·16 and 0·30 forward;

it is seen that no great error will be involved and considerable advantage will be gained, as it will be possible to simplify considerably the method of obtaining the floodable lengths. As will be seen later, it is also a great advantage to express the freeboard and sheer ratios in terms of the known quantity depth instead of the unknown quantity draught, for it eliminates the necessity of having to obtain the draught by the "trial and error" method.

SUGGESTED TABLE FOR OBTAINING FLOODING ORDINATES.

It is now necessary to ascertain a convenient method of tabulating the flooding ordinates when the above assumptions are made. Fig. 4 shows a straight line drawn through a cross curve of floodable lengths on a base of freeboard ratio $\left(\frac{\text{freeboard}}{\text{depth}}\right)$. The proposal is to assume that the straight line A B gives the required flooding ordinates instead of the curve E F. If the line A B is produced to meet the axis of X in C, the equation of the line is given by—

$$y = m\,(a + x)$$

where m is the slope of the line, and a is the intercept (C O) of the line on the axis of X beyond the origin. Thus any ordinate of the cross curve of floodable lengths represented by the straight line A B can be obtained if the values of m and a are known. Cross curves of floodable lengths on a base of freeboard ratios $\left(\frac{\text{freeboard}}{\text{depth}}\right)$ were obtained for the stations in the ship given by the Bulkhead Committee, for a permeability of 80 per cent., for block coefficients varying between 0·60 and 0·80 and for the highest and lowest assumed sheer ratios. Straight lines were then drawn through these curves between the above-mentioned limits of freeboard ratio in such a manner that the errors involved when the floodable length is obtained from the straight line instead of the curve are in every case the minimum possible. Variations in one quantity were set off against fluctuations in other quantities, and in many instances errors were in this manner completely eliminated.

From these graphs values of m and a were obtained, and are shown in Table I, page 96, from which it is possible to obtain a curve of floodable lengths for a permeability of 80 per cent. for any condition within the assumed limits by the formula—

$$l = m\,(a + f),$$

where l is the percentage floodable length; f, the freeboard ratio, is the ratio of the "freeboard" (measured from the subdivision load line to the lowest point of the margin line) to the "depth" (measured from the top of keel to the lowest point of the margin line). The margin line is parallel to the bulkhead deck at side line and 3 in. below the upper surface of that deck; m and a are factors obtained from the table.

Block coefficient is the displacement volume to moulded lines, divided by length on the subdivision load line multiplied by moulded breadth and by draught from top of keel. "Sheer ratio" (forward or aft) is the ratio of the "sheer" of the margin line at the ends (measured from a line drawn through the lowest point of the margin line parallel to the subdivision load line) to the "depth" (measured from the top of keel to the lowest point of the margin line). Values of m and a for block coefficients or sheer ratios intermediate between those given in the table are obtained by linear interpolation, and since it has been shown that the floodable length can be taken to vary inversely with the permeability, the floodable length for any permeability is given by—

$$l = \frac{80}{u}\,[m\,(a + f)] \quad . \quad . \quad . \quad (a)$$

when u is the permeability.

Correction for Form.—In the foregoing no account has been taken of the fifth item, namely of the "Form of Ship." Usually the effect of this correction is small, but in exceptional cases it may be large. It also generally increases the lengths of the flooding ordinates given by the Bulkhead Committee's diagrams (see Professor Welch, Trans. I.N.A., 1915, vol. lvii, page 14), and therefore its omission would be an error on the safe side.

The Bulkhead Committee assigned a permeability of 60 per cent. to all cargo spaces in a ship. It is obvious that this can only be an average figure, for the permeability of the holds of a vessel laden with iron ore would be considerably higher than 60 per cent., while on the other hand the permeability of the holds of a vessel laden with a very light substance (hemp, for example) would be much less than 60 per cent. In addition, it should be noted that the holds of the latter vessel would probably be full before the vessel was down to her maximum assigned draught, while in the former vessel there would be space in the holds for utilising considerably more than this maximum draught if it were permitted. Thus an assumption of 60 per cent. for the permeability of all cargo holds might not only involve errors due to the different natures of cargoes, but there might also be errors due to variation in freeboard ratio, especially on the homeward voyages. This question has been exhaustively examined by Mr. G. W. Barr, of Messrs. Alfred Holt and Co., by whose courtesy the results in Table II, page 97, are given. The freeboards and permeabilities shown in this table are worked out for actual voyages, and the permeabilities of most of the different kinds of cargoes were determined experimentally. It is seen that although the average of the actual permeabilities is not very different from that laid down by the Bulkhead Committee, yet the average errors in floodable lengths due to the variations in the freeboard ratios in actual practice is as much as 30 per cent. These errors, it will be noted, are in the direction of making the ship safer. It therefore appears that it is possible that the errors involved in assuming a fixed permeability for all cargoes, irrespective of their densities, might be much greater than those involved if the "Correction for Form" is omitted. While it must be recognised that permeability of 60 per cent. appears to be a reasonable mean value for cargo spaces, it does not, in view of the foregoing, appear to be unreasonable to omit the "Correction for Form" altogether, especially when it is remembered that this variable is the most difficult of all to take account of, and that its omission would be an error on the safe side.

Calculation of Permeability.—Under the present Board of Trade regulations it is necessary to ascertain the volumes of the various compartments in order to obtain the permeability. In the early stages of the design this information is not always easy to obtain, and the work would be simplified if the permeabilities could be based on figures which are readily available. It has been found that the following formula, embodying only figures obtainable from the middle-line section, gives the permeabilities very closely:

$$\text{Permeability} = 63 + 32\,\frac{h}{H} + C \quad . \quad . \quad (b)$$

where h is the mean depth below the bulkhead deck of the 95 per cent. spaces as defined in the present Board of Trade Regulations (exclusive of double bottom, peaks and tunnels), reduced in proportion which the mean length of such spaces bears to the length of the vessel measured between the forward machinery space bulkhead and the collision bulkhead, or between the aft machinery space bulkhead and the after peak bulkhead. The mean depth is to be measured from top of deck to top of deck at

* Paper read before the Institution of Naval Architects, July 7, 1920.

centre line. H is the depth of the vessel from the top of keel to the margin line midway between the end of the machinery space and the forward or after end of the vessel. C is zero for the forward end, 1 for the after end in single-screw vessels, and 2 for the after end in twin-screw vessels. The permeability of machinery spaces is taken to be 80 per cent. for steamships, and 85 per cent. for ships fitted with internal-combustion engines. This formula has been applied to the vessels given in Table II, and the results are included in that table. It will be observed that the formula gives results which are on the average within 0·5 per cent. of those obtained by the Board of Trade method. It is evident, therefore, that no appreciable error will be involved if this formula is used for obtaining the permeability. By means of the equation (a), Table I, and the equation for permeability (b), the flooding curve for any vessel can be obtained in about half an hour.

This method of obtaining flooding curves has been applied to a large range of ships, and it is found that the lengths of flooding ordinates obtained by this method are, on the average, within 2 per cent. or 3 per cent. of the floodable lengths obtained by the Bulkhead Committee's curves (but uncorrected for "form"). A typical example showing a comparison of curves obtained by these two methods is shown in Fig. 5, and a typical example showing the small amount of labour in the calculation is shown in Appendix I. It should be noted hat in obtaining values from Table II it is only necessary to read values of m to one decimal place, and values of a to three decimal places. For instance, suppose in the example given in Appendix I the value of m at 15 per cent. station was 52·7 instead of 52·6, then the value of the flooding ordinate would be 15·87 instead of 15·84. Similarly, if the value of a at the same station was 0·042 instead of 0·041, then the flooding ordinate would be 15·90, instead of 15·84. The differences in both of these cases is much too small to affect the results in actual practice.

Draught Penalty for a Long Hold.—It will be observed that this method of obtaining the flooding curves is not only simple of application and involves little labour, but also enables the draught penalty for a long hold to be obtained. Suppose in the example given in Appendix I that a hold 20 per cent. of the length of the vessel is required, with its centre of length at 70 per cent. station. The corresponding length of hold, if the permeability was 80 per cent., would be:

$$20 \times \frac{63}{80} = 15{\cdot}75 \text{ per cent. (permeability forward}$$

$$= 63 \text{ per cent.)}$$

$$15{\cdot}75 = m\,(a + f) = 56{\cdot}7\,(0{\cdot}050 + f)$$

$$f = 0{\cdot}228$$

and

$$f = \frac{\text{freeboard}}{\text{depth}} = \frac{\text{freeboard}}{35}$$

freeboard = 7·98 ft.

draught = 35 − 7·98 = 27·02 ft.

Reduction in draught = 28·0 − 27·02 = 0·98 ft.

i.e., draught penalty = 0·98 ft.

= 12 in (say).

The same method is applied for obtaining the correct permissible draught for a given spacing of bulkheads, if the first approximation should not be correct. It has been shown that the results obtained by this method of calculation agree quite closely enough for all practical purposes with those given by the Board of Trade method, and in view of the extreme simplicity of application and the enormous saving in time and labour which the method affords, it is considered that it could be very profitably substituted for the present laborious and intricate method of calculation.

On examining Table I, it will be seen that for a given station the difference between the values of m for the highest and lowest assumed sheer ratios is fairly constant for all block coefficients, and similarly for values of a. It therefore appears that Table I might be further simplified by giving values of m and a for one sheer ratio only instead of two, and giving for each station a correction factor, which would have to be applied if the sheer ratio differed from that for which the table was drawn up. Tables III and IV are drawn up on this basis, the values of m and a being correct for sheer ratios midway between the maximum and minimum sheer ratios of Table I—*i.e.*, the values of m and a in Tables III and IV are correct for sheer ratios of 0·115 aft and 0·23 forward, and the necessary correction for every 0·01 alteration in the sheer ratio is given for each station. These sheer corrections are correct for a block coefficient of 0·70 and in cases where the difference between the values of m (and a) for the two sheer ratios given in Table I are constant for all block coefficients, the sheer corrections of Tables III and IV will be correct for all block coefficients, and in those cases Tables III and IV would give exactly the same results as Table I. In most cases, however, the above-mentioned differences are not constant for all block coefficients; but it will be noted that when these differences for values of m increase with increase of block coefficient the corresponding differences for values of a decrease with increase of block coefficient, and *vice versa*. Thus, on examining the values of m and a obtained from Tables III and IV, it is seen that when the value of m obtained by Table III is less than that obtained from Table I the value of a by Table IV is greater than that obtained from Table I, and *vice versa*. Consequently, the flooding ordinates given by these two methods are in very close agreement.

For example, for a block coefficient of 0·62, the values of m and a at 80 per cent. station for sheer ratios of 0·30 are 55·4 and 0·077 respectively by Table I, and 55·05 and 0·078 respectively by Tables III and IV. Assuming a freeboard ratio of, say, 0·20, the former results give a flooding ordinate of $(55{\cdot}4 \times 0{\cdot}227) = 15{\cdot}35$, while the latter results give a flooding ordinate of $(55{\cdot}05 \times 0{\cdot}278) = 15{\cdot}35$. It is thus seen that Tables III and IV give results which are in close agreement with those given by Table I.

Slide Rule for Obtaining Flooding Curves.—It appears from the nature of Tables III and IV that it should be possible to construct a slide rule embodying the results contained in the tables. There are three variables to be considered—viz., block coefficient, sheer ratio, and m (or a). There are several ways in which these variables can be plotted in the form of a slide rule, but the simplest has been found to be as shown in Fig. 6. Values of block coefficients m and a are arranged on the fixed portion of the scale, while corrections to m and a for variations in sheer ratio are arranged on the sliding portion. It is found that by varying the scales for values of m and a at different stations, it is possible to make one scale of corrections for sheer ratio do for several stations, and thus the amount of data on the slide is reduced to a minimum.

On examining Table IV, it will be noted that at some of the stations the values of a do not increase or decrease continuously with increase of block coefficient (stations 15, 20, 70 and 80). Consequently, in these cases there will be two block coefficients for one value of a. This difficulty can be overcome in plotting by dividing the scale of block coefficients into two, at the point where the values of a stop descending and commence to ascend (or *vice versa*), one portion of the divided scale of block coefficients being arranged above the scale of a and the

Fig. 1. CROSS CURVES OF FLOODABLE LENGTHS.

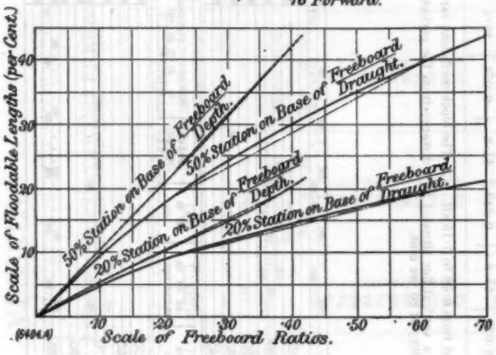

Block Coefficient = ·75
Permeability = 80%
Sheer Ratio (Sheer/Depth) = ·08 Aft. ·16 Forward.
Scale of Floodable Lengths (per Cent.)
50% Station on Base of Freeboard Depth.
50% Station on Base of Freeboard Draught.
20% Station on Base of Freeboard Depth.
20% Station on Base of Freeboard Draught.
Scale of Freeboard Ratios.
(6404.A)

Fig. 2. TYPICAL FLOODING CURVES.

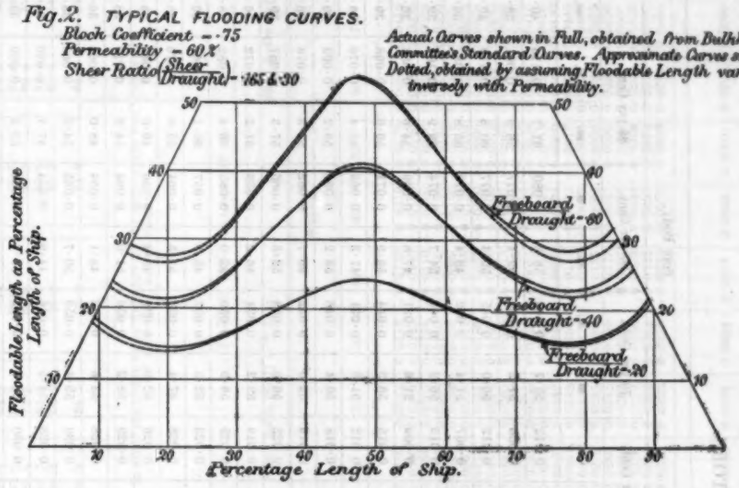

Block Coefficient = ·75
Permeability = 60%
Sheer Ratio (Sheer/Draught) = ·165 & ·30
Actual Curves shown in Full, obtained from Bulkhead Committee's Standard Curves. Approximate Curves shown Dotted, obtained by assuming Floodable Length varies inversely with Permeability.
Freeboard/Draught = ·60
Freeboard/Draught = ·40
Freeboard/Draught = ·20
Floodable Length as Percentage Length of Ship.
Percentage Length of Ship.

Fig. 3. CURVES SHOWING VARIATION IN FLOODABLE LENGTH BETWEEN HIGHEST AND LOWEST ASSUMED SHEER RATIOS.

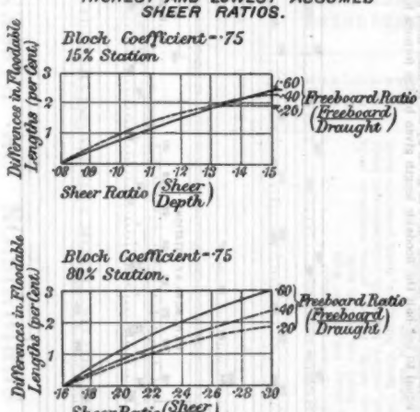


Fig. 4. DIAGRAM SHOWING STRAIGHT LINE DRAWN THROUGH CROSS CURVE OF FLOODABLE LENGTHS.

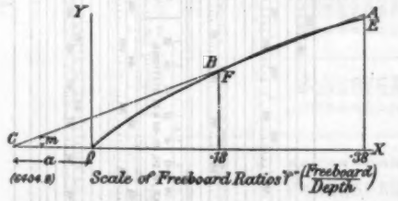
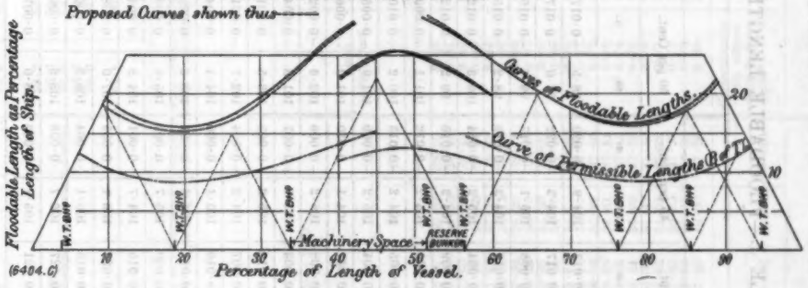


Fig. 5. TYPICAL CURVES OF FLOODABLE LENGTH BY THE BOARD OF TRADE RULES & BY THE PROPOSED METHODS FOR A VESSEL 560′ × 68′ × 43′.


Board of Trade Curves (Uncorrected for "Form") shown thus ——
Proposed Curves shown thus - - - -
Curve of Floodable Lengths
Curve of Permissible Lengths (Reg. I.)
W.T. Bhd
Machinery Space
RESERVE BUNKER
Floodable Length as Percentage Length of Ship.
Percentage of Length of Vessel.
(6404.C)

THE SUBDIVISION OF PASSENGER VESSELS.

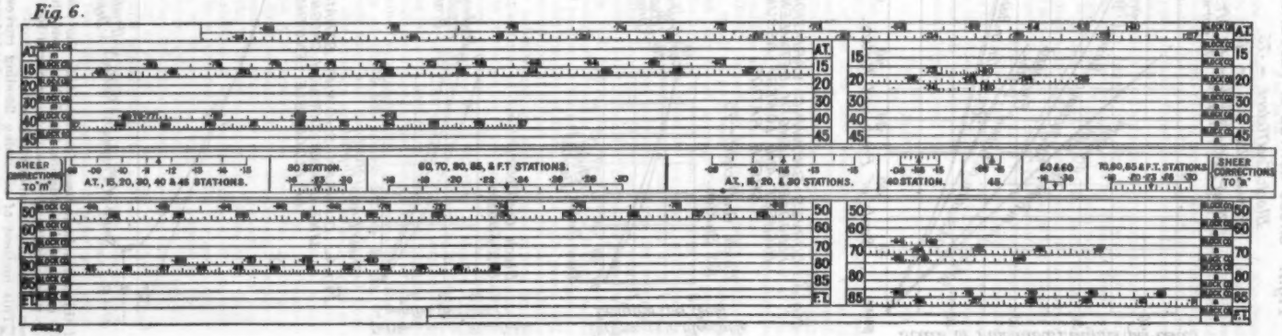
TABLE I.—FLOODABLE LENGTH FACTORS.

Block Coefficient.	Sheer Ratio.	After Body. A.T. m.	A.T. a.	15 per Cent. m.	15 per Cent. a.	20 per Cent. m.	20 per Cent. a.	30 per Cent. m.	30 per Cent. a.	40 per Cent. m.	40 per Cent. a.	45 per Cent. m.	45 per Cent. a.	Fore Body. 50 per Cent. m.	50 per Cent. a.	60 per Cent. m.	60 per Cent. a.	70 per Cent. m.	70 per Cent. a.	80 per Cent. m.	80 per Cent. a.	85 per Cent. m.	85 per Cent. a.	F.T. m.	F.T. a.	Sheer Ratio.	Block Coefficient.
0·60	0·15	41·2	0·275	57·4	0·077	57·7	0·045	66·9	0·021	96·3	−0·013	104·9	−0·020	98·5	−0·017	72·9	0·012	55·7	0·048	56·3	0·080	61·7	0·115	40·2	0·379	0·30	0·60
	0·08	40·0	0·250	55·9	0·044	55·2	0·018	63·7	0·001	92·0	−0·017	104·3	−0·022	97·0	−0·017	68·4	0·006	51·2	0·035	49·1	0·077	56·9	0·091	36·8	0·379	0·16	
0·62	0·15	40·9	0·268	56·6	0·072	56·8	0·044	66·0	0·024	95·3	−0·008	105·1	−0·017	99·4	−0·015	74·2	0·012	56·0	0·045	55·4	0·077	60·8	0·110	40·1	0·368	0·30	0·62
	0·08	39·4	0·248	54·9	0·041	54·2	0·017	62·8	0·004	91·2	−0·013	104·3	−0·019	98·2	−0·015	69·5	0·007	51·4	0·022	48·4	0·073	55·8	0·087	36·8	0·365	0·16	
0·64	0·15	40·6	0·261	55·9	0·067	55·9	0·043	65·1	0·027	94·4	−0·004	105·2	−0·014	100·3	−0·012	75·3	0·013	56·2	0·044	54·7	0·074	59·9	0·104	39·9	0·359	0·30	0·64
	0·08	39·0	0·244	53·9	0·037	53·2	0·016	62·1	0·006	90·4	−0·009	104·3	−0·016	99·2	−0·012	70·4	0·009	51·6	0·031	47·8	0·069	54·6	0·083	36·8	0·353	0·16	
0·66	0·15	40·4	0·253	55·2	0·062	55·1	0·041	64·4	0·029	93·6	0·000	105·2	−0·012	101·1	−0·009	76·2	0·015	56·3	0·044	53·9	0·071	59·0	0·098	39·6	0·350	0·30	0·66
	0·08	38·6	0·238	53·1	0·033	52·4	0·015	61·5	0·008	89·6	−0·005	104·2	−0·013	100·2	−0·010	71·0	0·012	51·8	0·031	47·3	0·065	53·4	0·079	36·7	0·341	0·16	
0·68	0·15	40·2	0·245	54·5	0·056	54·4	0·039	63·8	0·032	92·8	0·004	105·2	−0·009	101·9	−0·005	76·9	0·018	56·4	0·046	53·2	0·068	58·2	0·093	39·4	0·342	0·30	0·68
	0·08	38·3	0·229	52·2	0·028	51·6	0·014	61·0	0·009	88·9	−0·001	104·1	−0·010	101·0	−0·006	71·6	0·015	52·0	0·032	46·7	0·062	52·3	0·076	36·6	0·330	0·16	
0·70	0·15	40·0	0·235	53·9	0·051	53·6	0·037	63·3	0·035	92·1	0·008	105·2	−0·006	102·6	−0·002	77·6	0·022	56·6	0·048	52·5	0·066	57·3	0·087	39·1	0·333	0·30	0·70
	0·08	38·1	0·219	51·5	0·023	50·9	0·013	60·7	0·011	88·2	0·003	104·1	−0·007	101·8	−0·004	72·1	0·019	52·2	0·034	46·2	0·059	51·2	0·072	36·5	0·319	0·16	
0·72	0·15	39·9	0·225	53·2	0·046	53·0	0·036	62·9	0·038	91·5	0·012	105·2	−0·003	103·5	0·001	78·4	0·025	56·9	0·050	52·0	0·065	56·4	0·082	38·8	0·324	0·30	0·72
	0·08	38·0	0·207	50·7	0·018	50·2	0·012	60·6	0·012	87·6	0·007	104·2	−0·004	102·7	−0·001	72·8	0·023	52·5	0·037	45·8	0·057	50·1	0·069	36·4	0·308	0·16	
0·74	0·15	39·8	0·215	52·6	0·042	52·3	0·036	62·6	0·041	91·1	0·016	105·4	0·000	104·4	0·004	79·5	0·028	57·4	0·053	51·5	0·064	55·6	0·076	38·6	0·314	0·30	0·74
	0·08	38·0	0·194	49·9	0·015	49·5	0·012	60·5	0·014	87·2	0·011	104·4	−0·001	103·6	0·002	73·9	0·026	52·9	0·039	45·4	0·056	49·0	0·066	36·3	0·296	0·16	
0·76	0·15	39·7	0·203	51·9	0·040	51·7	0·038	62·5	0·044	90·9	0·020	105·7	0·002	105·6	0·006	81·0	0·029	58·2	0·056	51·0	0·064	54·9	0·070	38·4	0·303	0·30	0·76
	0·08	38·0	0·180	49·1	0·013	49·0	0·013	60·5	0·017	86·9	0·015	104·7	0·001	104·8	0·004	75·3	0·028	53·6	0·042	45·1	0·054	48·0	0·062	36·2	0·283	0·16	
0·78	0·15	39·7	0·190	51·2	0·040	51·1	0·014	62·5	0·048	90·9	0·023	106·1	0·005	107·0	0·008	83·1	0·030	59·4	0·059	50·7	0·065	54·2	0·065	38·4	0·288	0·30	0·78
	0·08	38·1	0·166	48·2	0·013	48·4	0·015	60·5	0·020	86·7	0·018	105·1	0·004	106·3	0·006	77·2	0·028	54·5	0·046	44·9	0·054	47·1	0·059	36·2	0·269	0·16	
0·80	0·15	39·8	0·176	50·3	0·041	50·5	0·046	62·6	0·052	91·0	0·027	106·7	0·008	108·6	0·009	85·6	0·030	60·9	0·062	50·4	0·066	53·5	0·059	38·5	0·272	0·30	0·80
	0·08	38·2	0·152	47·2	0·015	47·9	0·018	60·6	0·024	86·7	0·021	105·7	0·006	108·0	0·007	79·5	0·028	55·6	0·049	44·8	0·054	46·3	0·055	36·2	0·253	0·16	

This table applies to all cases where: (1) The freeboard ratio varies from 0·18 to 0·38. (2) The sheer ratio varies from 0·16 to 0·30 forward and from 0·08 to 0·15 aft. (3) The block coefficient varies from 0·60 to 0·80.

NOTE.—For the forward and after terminals the ordinate of the flooding curve as given by the formula must be plotted on a vertical line situated at a distance from the particular terminal equal to one-half the floodable length given by the formula for a permeability of 80 per cent.

Fig. 6.


SHEER CORRECTIONS TO 'm'
A.T., 15, 20, 30, 40 & 45 STATIONS.
50 STATION.
60, 70, 80, 85, & F.T. STATIONS.
A.T., 15, 20, & 30 STATIONS.
40 STATION.
45.
50 & 60
70, 80, 85 & F.T. STATIONS
SHEER CORRECTIONS TO 'n'

THE SUBDIVISION OF PASSENGER VESSELS.

TABLE II.—COMPARISON OF FLOODABLE LENGTH TO BOARD OF TRADE AND TO ESTIMATED ACTUAL PERMEABILITY TAKING FREEBOARD RATIO INTO ACCOUNT.

Ship.	Voyage.	Draught. Leaving.	Draught. Summer.	Freeboard Ratio = Freeboard / Draught. Leaving.	Freeboard Ratio = Freeboard / Draught. Summer.	Nature of Cargo.	Permeability, per Cent. Actual. Forward.	Actual. Aft.	To Board of Trade. Forward.	To Board of Trade. Aft.	Floodable Length Error due to Freeboard Ratio and Permeability. Forward.	Floodable Length Error due to Freeboard Ratio and Permeability. Aft.	Permeability by Proposed Formula $U = 63 + \left\{32\frac{A}{H}\right\} + C$. Forward.	Permeability by Proposed Formula Aft.	Percentage Error Proposed Formula and Board of Trade Method. Forward.	Percentage Error Proposed Formula and Board of Trade Method. Aft.
		ft. in.	ft. in.								Measured at 80 per cent. L from Aft end.	Measured at 20 per cent. L from Aft end.				
Ship "A"	5 home	28 6	31 3	0·405	0·282	Mutton, wheat, wool, skins	55·2	60·3	65·2	66·5	27·3	47·2	65·5	65·0	+0·5	−2·3
Ship "B"	5 ,,	24 0½	27 3	0·45	0·282	Tobacco, rubber, copra, sago	67·8	66·1	64·2	64·1	26·6	36·1	63·0	64·0	−1·9	nil
Ship "B"	6 ,,	26 1½	27 3	0·337	0·282	Copra, hemp, tea, rubber, nuts	60·9	56·5	64·2	64·1	18·0	27·3	63·0	64·0	−1·9	nil
Ship "B"	7 ,,	26 1½	27 3	0·337	0·282	Copra, hemp, tea rubber, nuts	65·5	61·1	64·2	64·1	10·6	17·85	63·0	64·0	−1·9	nil
Ship "C"	1 ,,	26 6	28 2	0·331	0·253	Tobacco, hemp, rubber, copra, sessamun seeds	60·0	57·7	64·1	64·0	24·9	28·8	63·0	64·0	−1·75	nil
Ship "C"	2 ,,	25 4½	28 2	0·391	0·253	Tobacco, rubber, hides, tea, nuts, sessamun seeds	63·5	63·3	64·1	64·0	29·5	29·5	63·0	64·0	−1·75	nil
Ship "C"	3 ,,	25 9	28 2	0·371	0·253	Tobacco, hemp, hides, tea, nuts, sessamun seeds	59·9	62·5	64·1	64·0	32·9	26·9	63·0	64·0	−1·75	nil
Ship "C"	10 ,,	26 1	28 2	0·354	0·253	Hemp, copra, hides	62·6	61·2	64·1	64·0	24·3	25·6	63·0	64·0	−1·75	nil
Ship "D"	12 ,,	28 5½	30 9½	0·495	0·382	Peas, rice, hemp, sago, copra	59·0	61·3	63·3	63·2	23·9	25·6	63·0	65·6	−0·5	+0·6
Ship "D"	21 ,,	26 4	30 9½	0·615	0·382	Hemp, flour, rubber, tea	56·6	53·7	63·3	65·2	46·4	68·5	63·0	65·6	−0·5	+0·6
Ship "E"	37 ,,	23 0½	25 3	0·387	0·285	Tobacco, sessamun seeds, nuts	65·3	64·5	63·3	63·7	19·7	23·7	63·0	64·0	−0·5	+0·5
Ship "E"	47 ,,	22 5 Indian Summer	25 3	0·425	0·265	Copra, rubber, Gambier	62·5	62·5	63·3	63·7	32·0	35·5	63·0	64·0	−0·5	+0·5
Ship "F"*	26 ,,	27 2½	26 8½	0·298	0·322	Rice	58·2	57·7	63·2	63·2	5·4	2·6	63·0	64·0	−0·3	+1·2
Ship "F"	27 ,,	25 8½	26 8½	0·373	0·322	Rice, copra, maize, beans	58·6	55·8	63·2	63·2	22·2	25·5	63·0	64·0	−0·3	+1·2
Ship "G"	6 ,,	24 1½	32 1½	0·763	0·324	Hemp and Lumber (passengers in 'tween decks)	64·5	64·7	69·6	71·8	65·0	82·5	69·1	71·25	−0·7	−0·8
Ship "G"	7 ,,	27 1	32 1½	0·57	0·324	Salmon, hemp, lumber	59·2	59·8	63·7	64·5	44·0	53·0	63·3	65·6	−1·1	+1·7
Ship "H"	10 ,,	25 5	27 3	0·374	0·282	Hemp, tapioca	59·0	57·3	64·2	64·1	28·9	36·5	63·3	64·0	−1·9	nil
Average	—	—	—	—	—	—	61·1	60·3	64·2	64·7	28·3	34·9	63·5	64·8	−1·09 per cent.	+0·155 per cent.

All the above examples, with the exception of ship "H," were taken at random—*i.e.*, voyages were not specially chosen. In all of the above cases the whole of the cargo space was occupied, except in the case of ship "G," voyage 6, when passengers were carried in 'tween decks.

* This vessel has no sheer.

TABLE III.—VALUES OF *m*.

Block Coefficient.	Sheer Ratio (S/D) = 0·115. Station. A.T.	15	20	30	40	45	50	60	70	80	85	F.T.	Sheer Ratio (S/D) = 0·23. Station. A.T.	15	20	30	40	45	50	60	70	80	85	F.T.
0·60	40·60	56·66	56·43	65·30	94·18	104·70	97·75	70·65	53·43	52·67	59·33	38·50	0·2625	0·0610	0·0315	0·0110	−0·0150	−0·0210	−0·0170	0·0085	0·0412	0·0790	0·1035	0·3788
0·61	40·40	56·20	55·95	64·83	93·70	104·70	98·30	71·25	53·60	52·29	58·83	38·46	0·2604	0·0590	0·0310	0·0125	−0·0130	−0·0195	−0·0160	0·0088	0·0398	0·0769	0·1010	0·3722
0·62	40·20	55·75	55·48	64·39	93·25	104·70	98·83	71·81	53·72	51·90	58·32	38·42	0·2580	0·0569	0·0305	0·0138	−0·0110	−0·0180	−0·0146	0·0092	0·0388	0·0749	0·0985	0·3665
0·63	40·00	55·32	55·01	63·98	92·82	104·70	99·32	72·33	53·82	51·56	57·80	38·38	0·2553	0·0547	0·0300	0·0150	−0·0090	−0·0165	−0·0132	0·0100	0·0380	0·0730	0·0960	0·3610
0·64	39·80	54·90	54·56	63·60	92·40	104·70	99·80	72·81	53·90	51·21	57·27	38·33	0·2523	0·0525	0·0294	0·0162	−0·0069	−0·0150	−0·0118	0·0110	0·0375	0·0712	0·0935	0·3555
0·65	39·65	54·50	54·14	63·25	92·00	104·70	100·25	73·24	53·96	50·88	56·73	38·26	0·2490	0·0501	0·0288	0·0174	−0·0048	−0·0135	−0·0104	0·0122	0·0375	0·0695	0·0910	0·3505
0·66	39·50	54·11	53·74	62·93	91·60	104·70	100·68	73·61	54·03	50·56	56·20	38·18	0·2454	0·0476	0·0281	0·0186	−0·0027	−0·0120	−0·0090	0·0135	0·0378	0·0679	0·0886	0·3455
0·67	39·36	53·73	53·35	62·65	91·21	104·70	101·09	73·93	54·11	50·25	55·70	38·09	0·2414	0·0449	0·0273	0·0197	−0·0006	−0·0105	−0·0075	0·0150	0·0383	0·0664	0·0862	0·3407
0·68	39·23	53·36	52·98	62·40	90·84	104·70	101·48	74·23	54·20	49·95	55·20	38·00	0·2370	0·0421	0·0265	0·0208	+0·0015	−0·0091	−0·0060	0·0167	0·0390	0·0651	0·0840	0·3360
0·69	39·12	53·00	52·61	62·18	90·49	104·70	101·85	74·53	54·30	49·65	54·70	37·90	0·2322	0·0393	0·0257	0·0218	0·0035	−0·0077	−0·0045	0·0185	0·0400	0·0640	0·0820	0·3312
0·70	39·03	52·65	52·25	61·99	90·16	104·70	102·24	74·85	54·40	49·37	54·21	37·80	0·2270	0·0367	0·0250	0·0228	0·0055	−0·0063	−0·0030	0·0203	0·0410	0·0630	0·0799	0·3263
0·71	38·96	52·30	51·90	61·83	89·86	104·70	102·65	75·21	54·58	49·12	53·73	37·70	0·2216	0·0342	0·0245	0·0238	0·0075	−0·0049	−0·0015	0·0222	0·0420	0·0620	0·0777	0·3214
0·72	38·92	51·96	51·57	61·70	89·60	104·70	103·08	75·62	54·70	48·88	53·27	37·60	0·2160	0·0320	0·0242	0·0248	0·0095	−0·0035	0·0000	0·0240	0·0430	0·0612	0·0755	0·3164
0·73	38·90	51·62	51·25	61·60	89·37	104·79	103·55	76·11	54·91	48·65	52·81	37·51	0·2103	0·0301	0·0242	0·0258	0·0115	−0·0022	+0·0013	0·0256	0·0445	0·0605	0·0733	0·3110
0·74	38·90	51·26	50·94	61·53	89·17	104·90	104·06	76·70	55·18	48·44	52·35	37·43	0·2044	0·0286	0·0242	0·0270	0·0135	−0·0009	0·0026	0·0270	0·0460	0·0600	0·0701	0·3052
0·75	38·90	50·88	50·63	61·50	88·01	105·03	104·62	77·39	55·52	48·24	51·90	37·36	0·1982	0·0275	0·0245	0·0284	0·0155	+0·0004	0·0038	0·0280	0·0475	0·0595	0·0689	0·2992
0·76	38·90	50·50	50·33	61·50	88·91	105·20	105·25	78·18	55·93	48·07	51·47	37·30	0·1917	0·0266	0·0252	0·0300	0·0173	0·0017	0·0050	0·0285	0·0490	0·0592	0·0666	0·2930
0·77	38·90	50·10	50·03	61·50	88·85	105·40	105·95	79·09	56·41	47·92	51·05	37·28	0·1850	0·0266	0·0263	0·0318	0·0191	0·0031	0·0060	0·0290	0·0507	0·0592	0·0643	0·2905
0·78	38·90	49·69	49·75	61·50	88·82	105·64	106·70	80·14	56·96	47·80	50·65	37·28	0·1782	0·0270	0·0279	0·0336	0·0208	0·0044	0·0068	0·0290	0·0525	0·0595	0·0620	0·2790
0·79	38·90	49·26	49·47	61·50	88·82	105·92	107·49	81·31	57·59	47·70	50·27	37·28	0·1712	0·0275	0·0298	0·0355	0·0223	0·0057	0·0074	0·0270	0·0540	0·0598	0·0595	0·2710
0·80	38·90	48·80	49·20	61·50	88·82	106·23	108·30	82·60	58·30	47·60	49·90	37·28	0·1640	0·0280	0·0320	0·0375	0·0238	0·0070	0·0080	0·0290	0·0555	0·0602	0·0570	0·2625
Correction for 0·01 alteration in sheer ratio*	0·371	0·344	0·397	0·357	0·557	0·157	0·0585	0·387	0·314	0·450	0·4375	0·180	0·0024	0·0040	0·0038	0·0034	0·0007	0·0002	0·0001	0·0002	0·0009	0·0005	0·0010	0·0010

* Correction to be {added / subtracted} according as sheer ratio is {greater / less} than sheer ratio of table.

TABLE IV.—VALUES OF *n*.

Block Coefficient.	Sheer Ratio (S/D) = 0·115. Station. A.T.	15	20	30	40	45	50	60	70	80	85	F.T.	Sheer Ratio (S/D) = 0·23. Station. A.T.	15	20	30	40	45	50	60	70	80	85	F.T.
0·60	0·2625	0·0610	0·0315	0·0110	−0·0150	−0·0210	−0·0170	0·0085	0·0412	0·0790	0·1035	0·3788	0·2625	0·0610	0·0315	0·0110	−0·0150	−0·0210	−0·0170	0·0085	0·0412	0·0790	0·1035	0·3788
0·61	0·2604	0·0590	0·0310	0·0125	−0·0130	−0·0195	−0·0160	0·0088	0·0398	0·0769	0·1010	0·3722	0·2604	0·0590	0·0310	0·0125	−0·0130	−0·0195	−0·0160	0·0088	0·0398	0·0769	0·1010	0·3722
0·62	0·2580	0·0569	0·0305	0·0138	−0·0110	−0·0180	−0·0146	0·0092	0·0388	0·0749	0·0985	0·3665	0·2580	0·0569	0·0305	0·0138	−0·0110	−0·0180	−0·0146	0·0092	0·0388	0·0749	0·0985	0·3665
0·63	0·2553	0·0547	0·0300	0·0150	−0·0090	−0·0165	−0·0132	0·0100	0·0380	0·0730	0·0960	0·3610	0·2553	0·0547	0·0300	0·0150	−0·0090	−0·0165	−0·0132	0·0100	0·0380	0·0730	0·0960	0·3610
0·64	0·2523	0·0525	0·0294	0·0162	−0·0069	−0·0150	−0·0118	0·0110	0·0375	0·0712	0·0935	0·3555	0·2523	0·0525	0·0294	0·0162	−0·0069	−0·0150	−0·0118	0·0110	0·0375	0·0712	0·0935	0·3555
0·65	0·2490	0·0501	0·0288	0·0174	−0·0048	−0·0135	−0·0104	0·0122	0·0375	0·0695	0·0910	0·3505	0·2490	0·0501	0·0288	0·0174	−0·0048	−0·0135	−0·0104	0·0122	0·0375	0·0695	0·0910	0·3505
0·66	0·2454	0·0476	0·0281	0·0186	−0·0027	−0·0120	−0·0090	0·0135	0·0378	0·0679	0·0886	0·3455	0·2454	0·0476	0·0281	0·0186	−0·0027	−0·0120	−0·0090	0·0135	0·0378	0·0679	0·0886	0·3455
0·67	0·2414	0·0449	0·0273	0·0197	−0·0006	−0·0105	−0·0075	0·0150	0·0383	0·0664	0·0862	0·3407	0·2414	0·0449	0·0273	0·0197	−0·0006	−0·0105	−0·0075	0·0150	0·0383	0·0664	0·0862	0·3407
0·68	0·2370	0·0421	0·0265	0·0208	+0·0015	−0·0091	−0·0060	0·0167	0·0390	0·0651	0·0840	0·3360	0·2370	0·0421	0·0265	0·0208	+0·0015	−0·0091	−0·0060	0·0167	0·0390	0·0651	0·0840	0·3360
0·69	0·2322	0·0393	0·0257	0·0218	0·0035	−0·0077	−0·0045	0·0185	0·0400	0·0640	0·0820	0·3312	0·2322	0·0393	0·0257	0·0218	0·0035	−0·0077	−0·0045	0·0185	0·0400	0·0640	0·0820	0·3312
0·70	0·2270	0·0367	0·0250	0·0228	0·0055	−0·0063	−0·0030	0·0203	0·0410	0·0630	0·0799	0·3263	0·2270	0·0367	0·0250	0·0228	0·0055	−0·0063	−0·0030	0·0203	0·0410	0·0630	0·0799	0·3263
0·71	0·2216	0·0342	0·0245	0·0238	0·0075	−0·0049	−0·0015	0·0222	0·0420	0·0620	0·0777	0·3214	0·2216	0·0342	0·0245	0·0238	0·0075	−0·0049	−0·0015	0·0222	0·0420	0·0620	0·0777	0·3214
0·72	0·2160	0·0320	0·0242	0·0248	0·0095	−0·0035	0·0000	0·0240	0·0430	0·0612	0·0755	0·3164	0·2160	0·0320	0·0242	0·0248	0·0095	−0·0035	0·0000	0·0240	0·0430	0·0612	0·0755	0·3164
0·73	0·2103	0·0301	0·0242	0·0258	0·0115	−0·0022	+0·0013	0·0256	0·0445	0·0605	0·0733	0·3110	0·2103	0·0301	0·0242	0·0258	0·0115	−0·0022	+0·0013	0·0256	0·0445	0·0605	0·0733	0·3110
0·74	0·2044	0·0286	0·0242	0·0270	0·0135	−0·0009	0·0026	0·0270	0·0460	0·0600	0·0701	0·3052	0·2044	0·0286	0·0242	0·0270	0·0135	−0·0009	0·0026	0·0270	0·0460	0·0600	0·0701	0·3052
0·75	0·1982	0·0275	0·0245	0·0284	0·0155	+0·0004	0·0038	0·0280	0·0475	0·0595	0·0689	0·2992	0·1982	0·0275	0·0245	0·0284	0·0155	+0·0004	0·0038	0·0280	0·0475	0·0595	0·0689	0·2992
0·76	0·1917	0·0266	0·0252	0·0300	0·0173	0·0017	0·0050	0·0285	0·0490	0·0592	0·0666	0·2930	0·1917	0·0266	0·0252	0·0300	0·0173	0·0017	0·0050	0·0285	0·0490	0·0592	0·0666	0·2930
0·77	0·1850	0·0266	0·0263	0·0318	0·0191	0·0031	0·0060	0·0290	0·0507	0·0592	0·0643	0·2905	0·1850	0·0266	0·0263	0·0318	0·0191	0·0031	0·0060	0·0290	0·0507	0·0592	0·0643	0·2905
0·78	0·1782	0·0270	0·0279	0·0336	0·0208	0·0044	0·0068	0·0290	0·0525	0·0595	0·0620	0·2790	0·1782	0·0270	0·0279	0·0336	0·0208	0·0044	0·0068	0·0290	0·0525	0·0595	0·0620	0·2790
0·79	0·1712	0·0275	0·0298	0·0355	0·0223	0·0057	0·0074	0·0270	0·0540	0·0598	0·0595	0·2710	0·1712	0·0275	0·0298	0·0355	0·0223	0·0057	0·0074	0·0270	0·0540	0·0598	0·0595	0·2710
0·80	0·1640	0·0280	0·0320	0·0375	0·0238	0·0070	0·0080	0·0290	0·0555	0·0602	0·0570	0·2625	0·1640	0·0280	0·0320	0·0375	0·0238	0·0070	0·0080	0·0290	0·0555	0·0602	0·0570	0·2625
Correction for 0·01 alteration in sheer ratio*	0·0024	0·0040	0·0038	0·0034	0·0007	0·0002	0·0001	0·0002	0·0009	0·0005	0·0010	0·0010	0·0024	0·0040	0·0038	0·0034	0·0007	0·0002	0·0001	0·0002	0·0009	0·0005	0·0010	0·0010

* Correction to be {added / subtracted} according as sheer ratio is {greater / less} than sheer ratio of table.

other portion below it (see Fig. 6). By means of this slide rule it is now possible to obtain the ordinates of the flooding curve for a ship in less than 10 minutes. The line of the cursor is placed over the required block coefficient for any given station. If the sheer ratio is normal (*i.e.*, 0·115 aft or 0·23 forward), the value of m (or a) can be read off from the scale of m (or a) immediately below the scale of block coefficients. If, however, the sheer ratio is not normal, the sliding scale is moved until the normal sheer ratio for the particular station is under the line of the cursor. The cursor is then moved until the line on it is over the required sheer ratio for the given station, and the value of m (or a) for the given station under the line of the cursor is read off. Knowing, therefore, the block coefficient and the sheer ratio, the values of m and a can be obtained for each station in the ship from the slide rule, and by the method shown in Appendix I the ordinates of the flooding curve can be quickly found.

APPENDIX I.

TYPICAL CALCULATION.

A typical calculation for the floodable length curve is as follows :—

s.s.....

$$452 \times 56{\cdot}0 \times 35{\cdot}25.$$

Depth to margin line	=	35·0
Moulded draught	=	28·0
Freeboard		7·0
Block coefficient		0·73
Freeboard ratio = $\frac{\text{freeboard}}{\text{depth}}$ ...		0·20
Sheer forward = 10·0 sheer ratio forward $\frac{\text{sheer}}{\text{depth}}$		0·286
Sheer aft = 5·0 sheer ratio aft $\frac{\text{sheer}}{\text{depth}}$		0·143

No passengers below bulkhead deck.

$\therefore u = 63$ forward, and 64 aft (per formula on page 5).

Station.	m.	a.	$a+f$.	Floodable Length. Machinery Space. $m(a+f)$	Floodable Length. Ends $\frac{80}{u}[m(a+f)]$
A.T.	39·7	0·218	0·418	16·58	20·75
15	52·6	0·041	0·241	12·67	15·84
20	52·4	0·034	0·234	12·24	15·30
30	62·5	0·037	0·237	14·81	18·51
40	90·9	0·014	0·214	19·45	24·30
45	105·2	0·002	0·198	20·84	26·08
50	103·9	0·002	0·202	21·00	26·65
60	78·4	0·026	0·226	17·72	22·50
70	56·7	0·050	0·250	14·18	18·00
80	51·1	0·064	0·264	13·49	17·13
85	55·3	0·078	0·278	15·36	19·50
F.T.	88·5	0·317	0·517	19·88	25·25

NOTE.—For the forward and after terminals, the ordinate of the flooding curve as given by the formula must be plotted on a vertical line situated at a distance from the particular terminal equal to one-half the floodable length given by the formula for a permeability of 80 per cent.

"STILL" AND "SULZER" MARINE ENGINES.

*Comparative Trials of "Still" and "Sulzer" Engines under Actual Working Conditions on Board Ship.**

By Mr. WILLIAM DENNY.

IN the year 1913, Messrs. William Denny and Brothers took out a licence from the firm of Sulzer Brothers, Winterthur, for their special type of oil engines. To obtain experience in the manufacture of such engines, they arranged to proceed with small twin-screw engines of about 250 i.h.p., in all, and to build a hull in which these engines would be thoroughly tested—both the hull and the power of the engines arranged for corresponded with a standard type of light draught passenger and cargo steamer, of which a number had been built for service in the rivers of India and Burmah. These vessels are 100 ft. long, 23 ft. 6 in. beam, and 7 ft. 6 in. deep, and have an approximate speed of 10 knots with 250 i.h.p. When war broke out the hull and engines for this experiment were well advanced, but under "control" conditions the work on them was stopped to make way for the pressing requirements of the Government.

For some time before the war the firm had been interested in the "Still" engine; fairly early in the war period it was arranged, with the consent of the Admiralty, that an experimental Still installation, to correspond with the hull already mentioned, should be proceeded with, being twin-screw engines of, in all, 250 i.h.p., or thereby. This arrangement was carried out and the vessel with the Still engine was exhaustively tried.

On the conclusion of the war it was decided to complete the original set of Sulzer engines and fit them to the same hull—the Still installation, so far as necessary, being, of course, removed from the vessel. This experiment also was duly carried out and the results with both types of engines are given later.

In carrying out these comparative trials everything possible was done to ensure that the results in all respects would be reliable—the same oil was used, the same propellers, the same draught, the vessel was run on the mile to check the speed in terms of revolutions, the oil consumption trials were repeated several times, and during each trial were checked at stated time intervals, and it is considered that the results as given may be regarded as reliable.

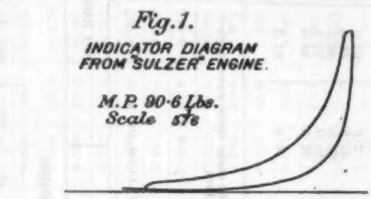
The Sulzer type of oil engine is well known, and the Still system has been fully described in a paper read by Captain F. E. D. Acland before the Royal Society of Arts on May 26, 1919, but, for the information of those who have not yet read that paper, it may be stated briefly that the Still type of engine is a combination of the steam and of the internal-combustion engine, steam acting on one side of the piston, while oil combustion takes place on the other side, within the same cylinder. A small boiler is part of the installation, from which the steam, generated by burning oil in the boiler in the usual way, is employed as the starting agent for the engine; the boiler also acts as a receiver for the steam derived from the waste heat of the exhaust gases of the internal-combustion part of the engine. The feed water is circulated by a pump drawing from the bottom of the boiler and discharging through the tubes of a generator, which is heated by the exhaust gases of the engine passing round the tubes; from thence the water passes to the cylinder jackets of the engine, where it is used as the cooling agent, thus gaining more heat, and thereafter returns to the boiler in the form of steam and water. The steam thus generated is used in the steam end of the cylinder, and adds to the power of the engine as a whole. The exhaust gases pass to the atmosphere on leaving the generator.

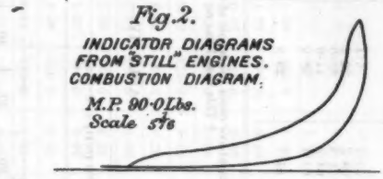
When the engine is running normally, *i.e.*, under "waste-heat" conditions, no fuel is burned in the boiler, the steam available being generated solely from the heat in the exhaust gases and from the heat transferred through the cylinder liner to the jacket water. The engine may be run at a considerable overload by augmenting the supply of steam through burning fuel in the boiler. Owing to the high temperature of the cylinder jacket cooling water (*i.e.*, boiler water), the compression pressure in the cylinder necessary for the ignition of the fuel is considerably lower than is the case in ordinary Diesel engine practice. The cycle of the steam portion of the engine is just as in ordinary steam practice, an air and circulating pump, condenser, boiler feed pump, &c., forming part of the installation.*

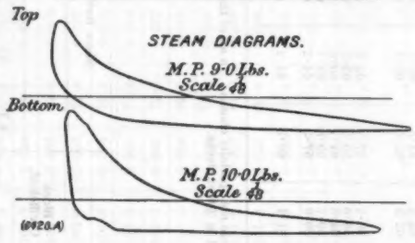
The Sulzer engines in question have cylinders approximately 8½ in. diameter by 13¾ in. stroke—four cylinders to each engine—and are of the two-cycle type. The Still engines have also four cylinders per set, 7½ in. diameter and 15 in. stroke, fitted with a boiler of the Yarrow type—they are of the opposed piston type and two-cycle.

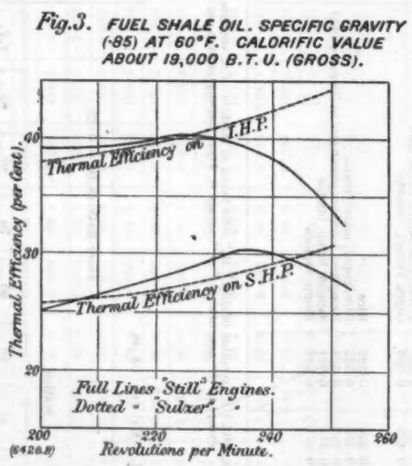
The Still engines were designed with a view to their powers of manœuvring being beyond question. It was suggested that a separate high-pressure cylinder might be fitted, the other cylinders being the second unit of the ordinary compound engine. By this means some economy might have been effected, but this complication was decided against. It may be added, while it has nothing to do with the question of relative economy of the engines, that the Still engines were arranged to run astern under steam only. Owing to this the boiler was larger than would be necessary in an engine arranged for astern working with oil also.

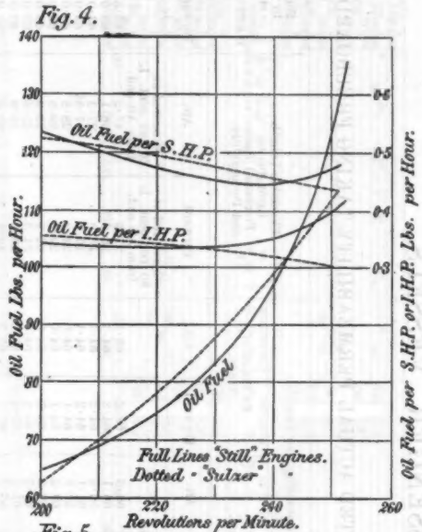
The Sulzer engines on the other hand were made to the patentee's design of 1913. Improvements have been made since then, and it is possible that some of these improvements may tend towards greater economy. It will be observed that the Sulzer engine cylinder capacity is considerably larger than that of the Still engine, which has an effect on the varying relative

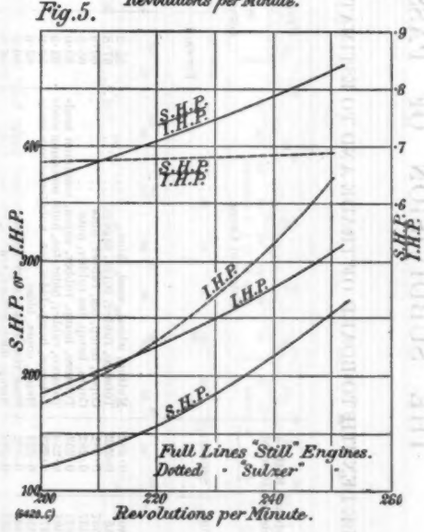












* Paper read before the Institution of Naval Architects, July 8, 1920.

* As the experimental engines in question were started, and manœuvred astern, under steam, and, as in this case, the solid oil injection principle was adopted, neither storage of compressed air nor compressor was necessary or provided.

"STILL" AND "SULZER" MARINE ENGINES.

Fig. 6. SULZER DIESEL ENGINE

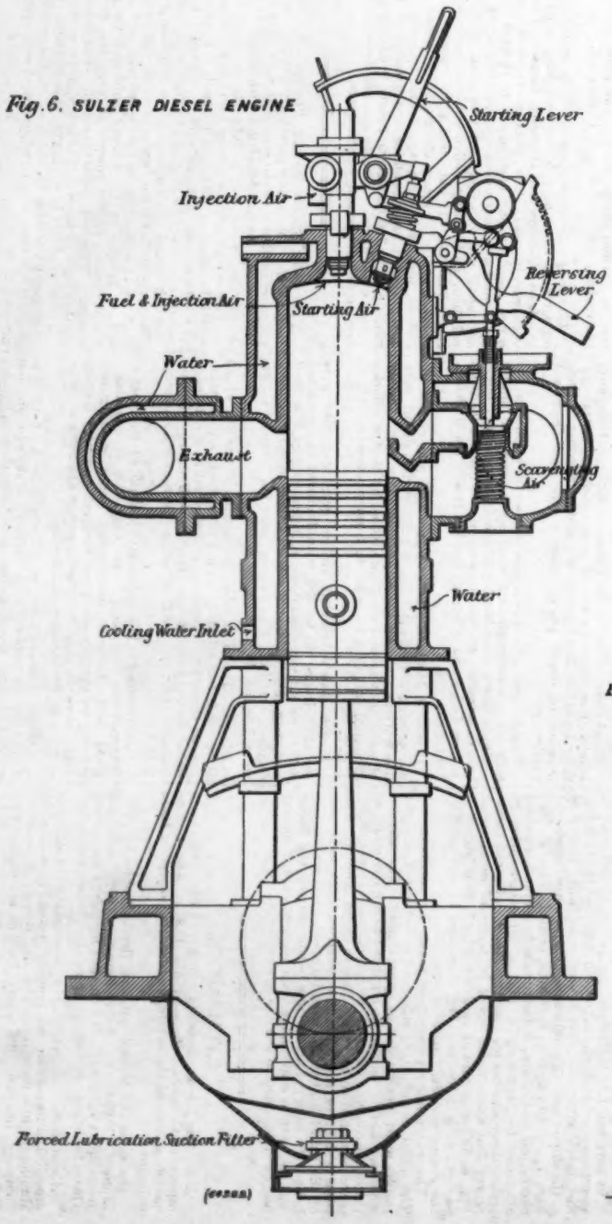
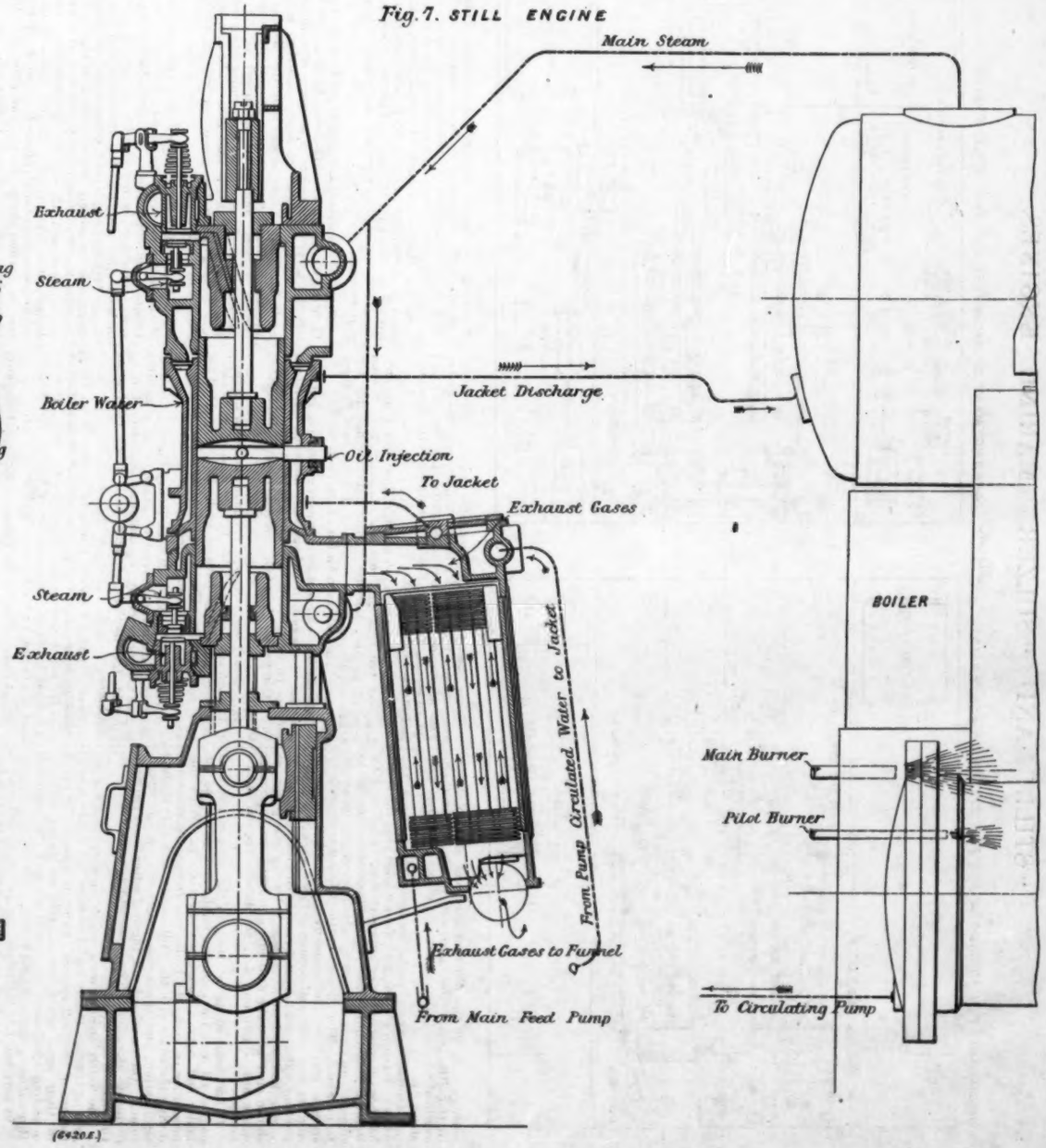


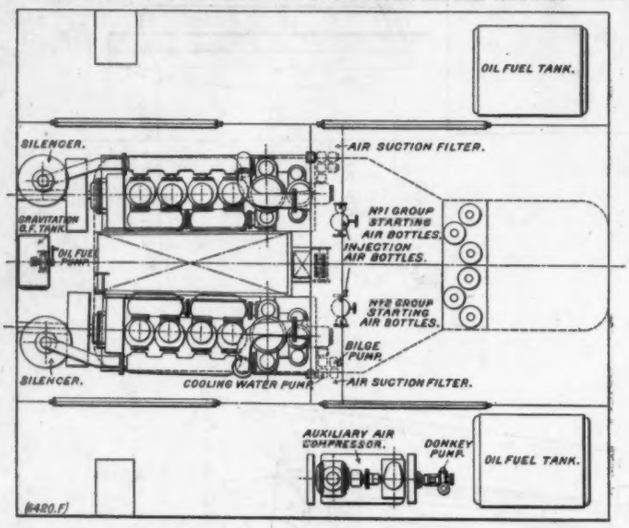
Fig. 7. STILL ENGINE



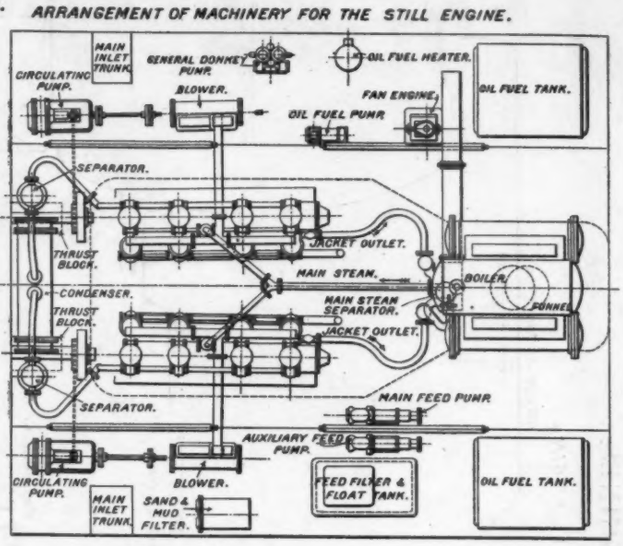
"STILL" AND "SULZER" MARINE ENGINES.

Fig. 8.

ARRANGEMENT OF MACHINERY FOR THE SULZER DIESEL ENGINE.



ARRANGEMENT OF MACHINERY FOR THE STILL ENGINE.



consumptions at the different numbers of revolutions. In the Still engine the maximum revolutions without overloading and without the use of oil in boiler were about 240.

A representative of each patentee was present at the trials of his own system, and was satisfied that the trials had been carried out in an approved manner. The trials were continued until these representatives were unable to suggest any modifications by which better results might be obtained. The oil used on the trials was shale 0·85 specific gravity. The manœuvring of both types of engines was quite satisfactory. From ahead to astern the time was about 5 seconds, and in this respect the Still engine had a slight advantage. During the trials, as shown on Fig. 4, the Still engine worked entirely under waste heat conditions, i.e., no oil was burned in the boiler.

It had been suggested that, in the case of the Still engine, oil from the cylinders might find its way to the boiler and have a dangerous effect on it. With this possibility in view, the boiler was frequently examined during the trials with the Still engine, and also at their termination, and there was practically no oil deposit found. On the other hand, the feed water filters required frequent attention. The generators remained clean throughout the trials.

The Sulzer engines were entirely constructed by the firm of William Denny and Brothers, but in the manufacture of the Still engines, owing to pressure of work in their own establishment, the assistance and co-operation of Messrs. T. A. Savery and Co., Limited, Birmingham, was arranged for.

In carrying out the trials, the principal aim was to ascertain accurately the oil used in terms of the speed of the vessel, being the point of view most likely to appeal to the shipowner. The following diagrams are appended: Fig. 1, Sulzer engine, indicator cards; Fig. 2, Still engine, oil and steam, indicator cards; Fig. 3, thermal efficiency (approximate); Fig. 4, oil consumption in terms of revolutions (or speed); Fig. 5, indicated horse-power and shaft horse-power in terms of revolutions. Fig. 6, Sulzer engine in section; Fig. 7, Still engine in section, with its boiler; Fig. 8, general arrangement of the Sulzer and Still installations.

The shaft horse-power was taken by torsionmeter. The facilities for fitting this gear were limited, and the results must be regarded as approximate. The thermal efficiency also is only to be regarded as approximate, as the exact calorific value of the fuel oil was not available; it was assumed to be 19,000 British thermal units. The total weight of the Sulzer installation is 25 tons, and of the Still installation, with its special accessories and boiler, 29 tons; but, as previously stated, the boiler was larger than would have been necessary if the engines had been designed to work astern under oil.

CATALOGUES.

Balancing and Rotating Bodies.—The Vibration Speciality Company, Philadelphia, U.S.A., send a more complete issue of the catalogue recently noticed in these columns.

Dynamos and Motors.—Messrs. Bruce Peebles and Co., Limited, Edinburgh, have issued a new catalogue describing their continuous current machines and giving a large list of powers, ratings, speeds and other particulars.

Aluminium.—An extremely interesting booklet of practical information on foundry practice in casting aluminium has been issued by the British Aluminium Company, Limited, 109, Queen Victoria-street, London, E.C. 4.

Power Rectifiers.—An illustrated article describing mercury arc rectifiers for large outputs, reprinted from *The Electrician* by Power-Rectifiers, Limited, 6, Old Queen-street, London, S.W. 1, contains very clear and useful descriptive matter.

Electrical Apparatus.—The Sun Electrical Company, Limited, 120, Charing Cross-road, London, W.C. 2, send a small booklet describing their lighting, heating and other apparatus with copies of French and Spanish editions. They also send a list of lamps in stock.

Cylinder Oil.—A graphite lubricant containing grit-free graphite in suspension and specially intended for motor car use is described in a catalogue from the Graphite Oils Company, Limited, George-street, Bridgeton, Glasgow.

Surveyors' Level.—Messrs. T. Cooke and Sons, Limited, 3, Broadway, London, S.W. 1, send a compact booklet describing their Zeiss pattern level which is adapted for easy and certain adjustment to a very fine degree of accuracy, and is light and safely portable.

Agricultural Tractor.—Messrs. Henry Garner, Limited, Moseley, Birmingham, send a catalogue of a paraffin engine tractor made by the Galloway Company, U.S.A., suitable for hauling ploughs and other cultivating machines.

Hard Copper.—Dawson hardened copper is an alloy, suitable for bearings, valves, gear wheels, bells and other uses for which pure copper would be too soft. It is an American product, the agents being Messrs. Wertheimer and White, 64, Victoria-street, London, S.W. 1.

Switch Gear.—The British Thomson-Houston Company, Rugby, have issued a new 30-page catalogue containing full particulars and explanatory matter relating to their ironclad oil-break switch gear of the non-draw out pattern.

Agricultural Machine Accessories.—An appliance for collecting loose grain and weed seeds from the binder machine and a draw-bar for attaching an ordinary horse cart to a tractor are the subjects of two catalogues from Messrs. Judge and Milstead, London Beach, St. Michaels, Tenterden.

Grinding Machine.—The Carson tool and cutter, or universal, grinding machine, is explained in detail, with illustrations showing the adjustment to a large variety of work, in a special catalogue issued by Messrs. Charles Churchill and Co., Limited, 9, Leonard-street, London, E.C. 2.

Switch Gear.—Ironclad switch gear and fuse gear for all voltages up to 600, manufactured in quantities and to recently-revised designs, is the subject of a brief and very clear catalogue received from Messrs. William Sandars and Co., Wednesbury, and 90, Charing Cross-road, London, W.C. 2.

Plough.—The Hamilton plough with power lift, which is suitable for working behind a tractor, and cutting two or three 10-in. furrows, is described in a catalogue issued by the International Harvester Company of Great Britain, Limited, 82, Finsbury-pavement, London, E.C. 2.

Gas Welding.—The quarterly journal of the Davis-Bournonville Company, Jersey City, U.S.A., contains a good deal of useful information about welding and cutting by the oxy-acetylene method, and very frankly emphasises the need for great care and attention in order to produce first-class workmanship.

X-Ray Examination of Materials.—A catalogue describing the application of X-Rays to the examination of metals and wood comes from the Cox-Cavendish Electrical Company, Limited, Acton-lane, Harlesden, London, N.W. 10. Steel plates and castings up to 2 in. thick may be examined by this means for flaws, porosity and other faults; while defects in electric and acetylene welds can also be detected. Internal knots, grub holes, resin pockets and similar defects, are also revealed in timber up to 18 in. thick. The company make sets of apparatus for various purposes and supply all auxiliary requirements.

Electrical Machinery.—The General Electric Company, Limited, 67, Queen Victoria-street, London, E.C. 4, have issued a general catalogue of 60 pages containing many interesting illustrations of heavy electrical machinery made by them. There is also tabulated lists of turbo-alternators, continuous-current generators, rotary converters, motors, and other machinery giving general particulars of the plant and mentioning the purpose for which it was installed in each case. The company have now over a dozen associated factories in addition to their plant at Wilton.

Portable Steam Engines.—Portable engines are described in a catalogue received from Messrs. Ruston and Hornsby, Limited, Lincoln. These are suitable for driving pumps, saws, threshing machines, mills and other machinery, in connection with building operations and farm work. Some 74 sizes, single and compound, are listed, with nominal horse-powers ranging from 2 to 35, but it should be noted that 2 nominal horse-power is equal to 4 effective horse-power and 12 nominal horse-power is equal to 40 effective horse-power. In all cases a maximum load of over 50 per cent. above the normal effective load can be carried temporarily. The catalogue gives full particulars, and is excellently illustrated.

Threshing Machines.—A very interesting example of portable machinery is the threshing machine made by Messrs. Ruston and Hornsby, Limited, Lincoln, and very widely used. The machine takes in the corn or other plant as cut and passes it through some nine operations in a continuous cycle, during which the straw and shaff are expelled and the grain is cleaned and polished, and finally delivered into sacks sorted into three qualities. It can deal with wheat, barley, oats or rye, and also, by means of some adjustments, with rape, linseed, mustard, carraway, beans, or peas. About a dozen sizes of the machine are listed with capacities ranging from 300 bushels to nearly 900 bushels of wheat a day, of 10 hours. A catalogue has been issued by the firm giving all necessary particulars.

TAR FROM STEAM POWER PLANTS.—In the journal *Braunkohle*, vol. xviii, pages 520 to 521, K. Wilkens proposes further to economise fuel and to produce a low-temperature tar in connection with steam boiler plants in the following way. Between the boiler and the economiser he inserts a large number of tubular retorts which he charges with coal through a hopper. Inside the retorts the coal is moved towards the end by means of a screw conveyor provided with hollow shafts through which the vapours are withdrawn by suction. The vapours and gas are cooled to condense the tar, and are then washed, again cooled and sent into a gas-holder, partly to be burned subsequently under the front portion of the retorts in order to dry the coal therein. The hot gases enter the economiser and are further utilised there. The experiments were made with the special object of improving the utilisation of the fuel in electricity works, in which so far the recovery of by-product has been only combined with some producer-gas processes.